For Editorial Contents see page 253

ENGINEERING LIBRARY

APR 2 1948

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY CHAS. COOPER AND J. FOSTER PETREE.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD ST., STRAND, LONDON, W.C.2.

VOL. 165—No. 4285 *Registered at the General Post Office as a Newspaper* *LONDON: FRIDAY, MARCH 12, 1948.* PRICE 1s. 6d. POSTAGE {INLAND 2½d. FOREIGN 3d.

Air Receivers Buoys, Road Wagons, Tanks **TANKS** Hoppers, Chimneys, Ducting.
EVERYTHING FROM MILD STEEL PLATE
JOHN BELLAMY
EAST 1892 LIMITED MILLWALL, E.14 EST. 1860 1216

FRASER BOILERS
FOR
HIGH PRESSURE TESTING OF VALVES, ETC.
FRASER & FRASER, LTD., Bromley-by-Bow, London, E.3. 5863

METAL SLITTING SAWS
GROUND FLAT STOCK
WILLIAM WARD & SON (SHEFFIELD), LTD., CENTENARY WORKS, WOODSEATS ROAD, SHEFFIELD 5388

J. & E. HALL
REFRIGERATION
FOR LAND & MARINE PURPOSES
LIFTS AND ESCALATORS
J. & E. HALL, LTD., ENGINEERS, DARTFORD KENT.
Telephone Dartford 3456
London Office: 10, St. Swithin's Lane, E.C.4.
Telephone: Mansion House 9811
5492

SPENCER-BONECOURT
Patent Waste Heat Boilers
34/36, Farringdon Street, E.C.4. 5674

BIBBY COUPLINGS
5200

SQUARE HEAD SETSCREWS
BRIGHT AND HARDENED TYPES
H. FORDSMITH LTD.,
Hadfield Street Works, Cornbrook, MANCHESTER, 16.
TRAfford Park 1615 and 1616 5589

LOCOMOTIVES
STEAM OR DIESEL
HUDSWELL CLARKE & Co. Ltd.
RAILWAY FOUNDRY, LEEDS
London Office: 46, Victoria St., S.W.1.
Telephone: Victoria 1133 8559

SECTIONAL PRESSED STEEL TANKS
also
RIVETED and WELDED PLATEWORK, STORAGE TANKS, BUOYS CHIMNEYS, BUNKERS, HOPPERS, Etc.
BROWN, LENOX & CO. (LONDON), LIMITED.
Contractors to the Admiralty since 1808
MILLWALL LONDON E.14.
Telephone: East 3261/2. 5691

YARROW
& CO., LTD.
GLASGOW
SHIPBUILDERS
MARINE ENGINEERS 5678
LAND AND MARINE BOILER MAKERS

BROTHERHOOD REFRIGERATION PLANT
PETER BROTHERHOOD LTD
PETERBOROUGH 6938

TATTERSALL
& SONS LTD.
BRICK CHIMNEYS, STOVES, BLAST FURNACE LININGS.
EST. 1898. 137, SOUTHFIELD RD., MIDDLESBROUGH

PUMPS.. Tel.
London Holborn 4271 (5 lines) Newark 601-2-3-4
Manchester Blackfriars 3810 Newcastle 22333
Birmingham Midland 5310 Glasgow Douglas 1974
Liverpool Central 1877
WORTHINGTON - SIMPSON

FORGINGS.
WALTER SOMERS, LTD.,
HALES OWEN 7115

DREDGERS
OF ALL TYPES
FERGUSON BROS. (Port-Glasgow) LTD
PORT-GLASGOW 5290

BARRY SCREENS
BARRY, HENRY & COOK, LTD.
ABERDEEN. 5586

TAYLOR AND CHALLEN POWER PRESSES
TAYLOR AND CHALLEN LIMITED 2858
DERWENT WORKS, BIRMINGHAM, 19

ELECTRIC SALINOMETERS
FEED WATER FILTERS,
VALVE RESEATERS.
W. CROCKATT & SONS, LTD.
DARNLEY STREET - GLASGOW 5819

HEATING & VENTILATION
ROSSER & RUSSELL LTD.
HEATING AND VENTILATING SPECIALISTS
30/31, Conduit Street, London, W.1. Tel. No. Mayfair 9141
Bank Low Mills Marsh Lane, Leeds, 9 Tel. No. Leeds 20911
5480

RAPIER
EXCAVATORS
and
WALKING DRAGLINES
RANSOMES & RAPIER LTD. Ipswich - England 5190

CRADLEY BOILERS
CRADLEY BOILERS CO. LTD.,
CRADLEY HEATH, STAFFS. 5585

MUREX
Electrodes
MUREX WELDING PROCESSES LTD.
WALTHAM CROSS, HERTS. 5214
Telephone: Waltham Cross 3636

PATTERNS
WOOD & METAL
B. LEVY & CO.
1, OSBERT STREET, VINCENT SQUARE, S.W.1
Telephone: VICtoria 1073 & 7486.

CRANES
GEORGE RUSSELL & CO., LTD.
Motherwell 5632

WAGONS
HURST NELSON & CO., LTD.,
MOTHERWELL

VISCO
AIR FILTERS
DUST COLLECTORS
COOLING TOWERS 5292
THE VISCO ENGINEERING CO., LTD.
Stafford Road, Croydon.
Phone: CROydon 4181/4 & 2471

SPECIAL MACHINERY MADE TO ORDER
'Phone: EUSTON 3176 (4 lines).
GEORGE WAILES & CO. LTD.
382-8 EUSTON RD., LONDON, N.W.1.
Specialists since 1855

WISEMAN REDUCTION GEARS
ALFRED WISEMAN & CO. Ltd.
GLOVER STREET, BIRMINGHAM, 9.

RESEARCH
ENGINEERS LTD
FOR
PROTOTYPES
FOR DETAILS
SEE FIRST CLASSIFIED PAGE

MOSS GEARS
GEARS ARE BETTER
THE MOSS GEAR CO., LTD.
Crown Works, Tyburn, Birmingham. 5731

COOPER SPLIT ROLLER BEARINGS
KING'S LYNN 5381 NORFOLK

GREENINGS WOVEN WIRE
OF ALL TYPES.
WARRINGTON, LANCS. HAYES, MIDDLESEX

44 HOUR WEEK
CALCULATORS IN STOCK COVERING ALL RANGES OF WAGES UP TO £10 PER WEEK. ALSO BOOKS FOR OTHER HOURLY WEEKS, RATES PER HOUR, PERCENTAGES, WEIGHTS RECKONERS, ETC. Over 60 Years Service.
Write for Price List.
F. H. WAKELIN LTD., Calculator Specialists, Printers and Publishers, 354 WHEELER STREET, BIRMINGHAM 19.
'Phone: Nor 0989. 'Grams: "Reckoners," B'ham

STEPHENS V-BELT DRIVES
Send for copy of V-Belt Drive Data Chart
STEPHENS BELTING CO. LTD
V-DRIVE WORKS,
SNOW HILL, BIRMINGHAM, 4

ALLDAYS & ONIONS
5353 BIRMINGHAM LTD.
BLOWERS ROOTS AND ROTARY

WEIR FEED PUMPS
G. & J. WEIR LTD. GLASGOW.

SAMUEL **PLATT** LIMITED
King's Hill Foundry, Wednesbury, Staffs
UPSET FORGING MACHINES
DROP STAMPS, PRESSES, DRAWBENCHES 5354

PATERSON
SPECIALISTS
IN ALL FORMS OF
WATER TREATMENT
FOR
MUNICIPAL
AND
INDUSTRIAL
PURPOSES 5533
83, KINGSWAY, LONDON

THOSE EXTRA RIVETS . . .

. . . CAN BE CLOSED MORE QUICKLY with Armstrong Whitworth Riveting Hammers. The secret lies in their light weight in relation to high power, achieved by means of extremely rapid blows. They are the ideal Riveting Hammers for all classes of riveting in Shipyards, Steel Framed Buildings, and Locomotive Erecting and Repair Shops. The full range of Riveting Hammers are capable of closing hot rivets up to 1¼" diameter.

The Close Quarter Riveter will be found convenient for use in restricted spaces. There is also a most comprehensive range of Rivet Snaps to meet every requirement.

Enquiries are invited regarding Pneumatic Tools for all engineering purposes.

ARMSTRONG WHITWORTH

& CO (PNEUMATIC TOOLS) LIMITED

PNEUMATIC TOOLS · AIR COMPRESSORS

AIR PUMPS LIMITED · LONDON

5516

Central Sales Office

ARMSTRONG WHITWORTH & CO., (PNEUMATIC TOOLS) LTD.,

CLOSE WORKS, GATESHEAD-ON-TYNE, ENGLAND.

Telephone: Gateshead 71261. Cables & Telegrams: "CLOSEWORK" Gateshead-on-Tyne.

RAISING GROUND LEVEL BY SAND PUMPING.

THE steelworks of Messrs. John Summers and Sons, Limited, at Shotton, near Chester, are situated on low ground close to the River Dee, where it runs out to the estuary. An extension, known as No. 3 steelworks, is to be built on a site to the north of the existing works, alongside the railway line to Seacombe (former London and North Eastern Railway Company); and, for this purpose, the ground is being raised to various levels, the maximum increase in height above the existing level being about 37·5 ft. The raising of the ground is being undertaken by the Westminster Dredging Company, Limited, 7 and 8, Norfolk-street, Strand, London, W.C.2, who are employing a suction dredger to lift sand from the Dee and pump it through a long pipeline to the site.

A photograph giving a general view of the existing works, the new site, dredger and pipeline is reproduced in Fig. 1, on this page. The site is the light strip of ground in the left background. A view of the dredging area in relation to the main channel of the Dee, looking downstream, is given in Fig. 2, and a map of the whole area is reproduced in Fig. 3, on page 242. It will be seen from Figs. 1 and 2 that the dredger is working in the lee of an existing groyne, which abuts on the end of a wharf served by a railway track. Fig. 4, on page 242, shows the disturbed state of the water when the tidal bore of the river sweeps by. The bore is about 18 in. high, and its passage up the main channel causes two or three lateral surges of water into the dredged backwater, which rock the dredger and floating pipeline. The low-lying marshy land on the steelworks side of the river is protected from inundation at high tide by a dyke, which is doubled in the area along the side of the river between the wharf and the works. A stream which follows an irregular course across the marshes passes through culverts in the two dykes and discharges into the river, as shown in Fig. 4. At high tide the outer culvert is closed, and the discharge from the stream through the inner culvert is temporarily contained in the area between the dykes. The solid material in suspension, pumped by the dredger from the Dee, is wholly fine sand.

FIG. 1. GENERAL VIEW, LOOKING EAST.

FIG. 2. DREDGING SITE, LOOKING DOWNSTREAM.

The site of the fill for the new steelworks is roughly triangular, with a road on the west, the railway on the east, and the existing steelworks on the south, as shown in Fig. 3. The steelworks buildings will be erected on the irregular strip on the west side, but most of the triangular area is to be raised. The ground was formerly about 15 ft. above datum, and the heights of the principal parts of the fill are shown in Fig. 3. It will be seen that the highest part is to be 52·5 ft. above datum, for which it is necessary to raise the ground about 37·5 ft. On the east side of the site there is to be a sloping approach for a railway line inclined at 1 in 100. Two views of the site from the air are given in Figs. 5 and 6, on page 252. The photographs were taken when the northern half of the fill was being pumped, and show the road, railway and pipeline. It is estimated that 1,700,000 cubic yards of sand are required for the fill, and the distance of the pipeline outlet from the dredger, when operating at the greatest range, is about 3,300 yards.

The dredger is a new type, designed by the Westminster Dredging Company, and the contract at Shotton is the first on which it has been employed. It has no propelling machinery, but may be transported to a site in sections and assembled in the water. A 2,200-volt alternating-current motor, supplied with electricity by cable from the shore, drives a centrifugal pump which sucks and delivers through 26-in. diameter pipes. The end of the suction pipe will reach to a depth of about 50 ft. in the river. Cutter gear is provided, but, of course, it is not required for pumping the sand of the Dee. The dredger is connected to the land pipeline by a floating pipeline which is shown in Figs. 7 and 8, on page 252. It was constructed in this country from the only suitable materials that were available. Reference to Figs. 4 and 7 will show that it consists of ten sections of pipe, supported on the shore at one end, by the dredger at the other end, and by nine pontoons in between. Each section consists of three 26-in. pipes, each 20 ft. long, bolted together at the flanges, and the sections are joined by rubber sleeves to allow movement. As the pipe was not strong enough to support the weight of the sand and water, it was necessary to brace the sections by constructing a frame of angle-iron, as shown in Fig. 8. The pontoons were built up from "Naval Lighterage" (N.L.) pontoon equipment, which consists of any desired number of separate units, each 7 ft. wide, 5 ft. long, and 5 ft. deep, and weighing 1¼ tons. Eight of the pontoons each consist of two rows of seven units, and the pontoon next to the dredger is doubled, as shown in Fig. 7. The section of pipe shown in the foreground has an elbow at each end, which is free to swing in the horizontal plane for approximately 180 deg. about a joint on the dredger and another on the double pontoon. A similar joint is provided on the double-pontoon end of the next section of pipe, and there is a length of pipe fixed in the double pontoon, between the two swivelling joints. This arrangement allows the dredger to be moved in relation to the pipeline, to sweep a large area of the river bed. The other eight sections of the pipe are supported at the ends, on brackets mounted on turntables on the pontoons. The turntables permit the pontoons to swing into the flow of the river, so that the pipeline may be used in a strong current.

The rubber sleeves will allow up to 30 deg. of movement of one pipe relative to the next, and, in order to use the whole of this movement for sweeping the dredging site, some of the pipes are fitted with short 165-deg. elbows at the ends, so that the 30-deg. sweep is wholly on one side of the in-line position of the two adjacent pipe sections. The significance of this is apparent from Fig. 1: the roughly circular lay-out of the floating pipeline is required on only one side—the river side—of the shore pipeline. The length of pipe between the dredger and the double pontoon is free to pivot about a horizontal axis at each end, to allow for the rise and fall of the dredger (Fig. 7). The electric cables for the dredger are carried on the floating pipeline, which is provided with a cat-walk and several air-

release valves and sluice valves. The dredger and the pipeline are anchored to the river bed, but as pumping proceeds the dredger is winched forward on the anchor cables, dragging the pipeline after it. The course of the land pipeline is shown on the map, Fig. 3, and in Fig. 1. There is a pumping station about half-way along, with a 500-h.p. motor driving a centrifugal pump through reduction gearing at 190 r.p.m., to boost the pressure when the combined effect of the length of the pipeline and the vertical head to be overcome exceeds the capacity of the dredger pump. It has been found, however, that the pumping station is not often required, the dredger being capable of most of the work. As shown in Fig. 6, the pipeline bridges the road alongside the filling site, and thence is laid to various points on the site.

Pumping was begun in August, 1947, and it is hoped to complete the work in June of this year. The site for the fill was first carefully surveyed, and a general plan for pumping was decided upon. This is a matter which calls for experience rather than theoretical knowledge, and, as pumping proceeds, the behaviour of the sand and water as they flow over the site is observed continuously. A quantity of top soil was first removed from a part of the site (the light area in the foreground of Fig. 6) and deposited outside the area. When the fill is complete, this top soil will be laid on the sand to consolidate it and protect it from strong winds. A bund was constructed around the perimeter of the proposed fill (except by the railway, the embankment of which sufficed) by drag-line excavators which removed the top soil of a narrow strip of ground inside the bund. A bund was also built to divide the area approximately into halves. and the northern half was pumped first, as shown in Fig. 6.

The principal factors to be observed when pumping is in progress are the proportion of sand to water, the drainage of water away from the site, and the rising level of the fill. A certain proportion of water in the pipe is essential to prevent a stoppage ; on the other hand, too much water is uneconomical and increases the work on the maintenance of the banks. In general, approximately 30 per cent. of the total volume of matter pumped was sand, and the remainder was water. About 1,000 cubic yards of sand are pumped per hour, and the pumping time is usually about 10 hours to 12 hours a day. Before stopping the dredger for the night or week-end, the suction pipe is raised from the bed of the river and water alone is pumped for about half an hour. This cleans the pipeline and ensures that there is no danger of a stoppage occurring on re-starting. It is also necessary to cease pumping for a short time at the beginning of flood-tide. In order to prevent the sand and water damaging the impeller-shaft gland, clean river water is applied to the other side of the gland at a greater pressure, but the object of doing so would be defeated if water with sand in suspension—as at the beginning of flood-tide—were to be pumped.

The dredger, the intermediate pumping station (when in use), and the pipeline outlet at the fill are connected by telephone, and the men at these points frequently communicate with each other about the progress of pumping. Normally, conditions are considered to be satisfactory when the pressure in the dredger suction pipe is approximately 7 lb. per square inch absolute (40 cm. of mercury), the pressure at the outlet of the pump is 50 lb. to 55 lb. per square inch, and there is a steady flow of sand and water at the pipeline outlet on to the site. A constant watch has to be kept because, for example, it is quite possible for the man at the site to observe a marked reduction in flow, owing to a stoppage near his end of the pipeline, some time before the man on the dredger notices a rise in outlet pressure. In such a case, after receiving the message by telephone, the dredger operator raises the suction pipe and pumps mostly water until the pipe is clear. Quite apart from the correction of such incidents, however, the dredger operator is continually adjusting the position of the suction pipe to ensure that the correct proportion of sand to water is being pumped. He observes the vacuum and pressure gauges, and "inches" the dredger forward by working the anchor winches, thus gradually feeding the end of the suction pipe over the river bed. If the outlet pressure is seen to increase beyond the normal value, the suction pipe is raised to reduce the proportion of sand ; or, conversely, if the pressure falls, either the dredger is inched forward (the normal procedure), or the suction pipe is lowered farther into the river bed.

When the work was started in August, 1947, the sandbank shown on the east side of the groyne in Fig. 3 was uncovered at low tide. It was found that, at high tide, there was just sufficient depth of water above the sandbank, at a point near the end of the groyne, to float the dredger over into a deeper part. Dredging was then commenced, and it is expected that most of the sandbank will have been removed when the fill is complete. The aerial photographs of the river were taken during September, 1947, when a part of the sandbank had been dredged. It is of interest to record that an old stone-built groyne has been exposed by the removal of the sand. The photographs do not show it, because it is now covered by the river water. From time to time, it is necessary to shorten that part of the land pipeline which runs parallel to the dyke (Fig. 4), to enable the dredger to sweep farther eastwards.

RAISING GROUND LEVEL BY SAND PUMPING.

Fig. 3.

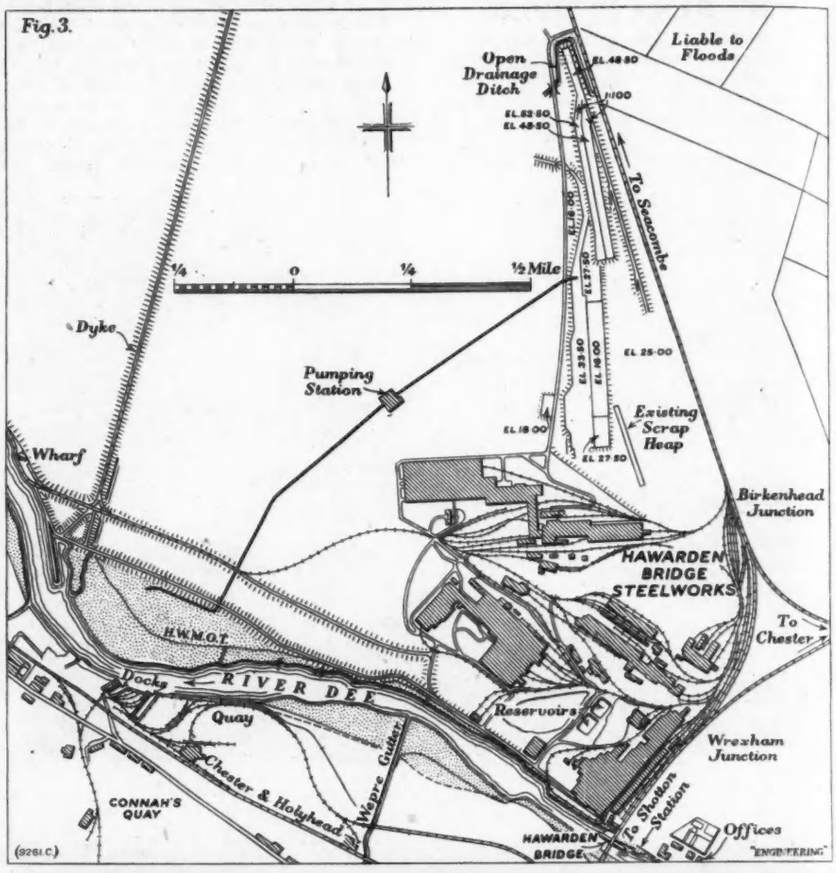


FIG. 4. TIDAL BORE OF RIVER FLOODING DREDGING AREA.

The vertical head to be overcome in sucking the sand and pumping it to the maximum height of the fill is almost 100 ft.; this is in addition to the frictional resistance in the suction and delivery pipes. Low-water level is approximately 3 ft. above Ordnance datum, and the suction pipe of the dredger reaches to a depth of not more than 45 ft. The several levels of the completed fill are shown as heights above datum in Fig. 3. As previously mentioned, the maximum height of the fill is 52·5 ft., and this, added to the depth of the suction pipe below datum, makes 97·5 ft.—nearly 100 ft. Generally, however, the vertical head is less than this; the average height of the site above datum, before pumping commenced, was 15 ft., and the maximum head is not attained until the final stage of pumping to the highest point of the fill.

A large wooden grid is placed below the outlet of the pipeline on the fill, to arrest the rush of water and thus prevent the formation of a crater due to scour. When pumping is in progress, the discharged sand spreads over the area of the fill between the bunds, with the water on top, and eventually assumes an angle of repose of about 1 in 90. The water is drained off through an outlet box. When pumping the first half of the fill, an outlet box was placed at the extreme northern tip (the farthermost end in Fig. 6), and the water drained into the stream, already mentioned, which follows a winding course in a general W.S.W. direction to the River Dee at a point adjacent to the dredging area. The weir of the outlet box is formed by wooden boards, and, as the level of the sand in the fill rises, more boards are added to raise the weir, the edge being maintained an inch or so above the sand. The accuracy with which an area can be raised by pumping will be better appreciated when it is stated that, by pumping alone, without subsequent mechanical levelling, the height is determined to within a tolerance of ± 4 in. Furthermore, the fill thus formed is solid and does not settle after the water has been drained off.

LITERATURE.

Influence Lines: Their Practical Use in Bridge Calculation. By D. S. STEWART. Second edition. Constable and Company, Limited, 10, Orange-street, London, W.C.2. [Price 12*s.* 6*d.* net.]

ALTHOUGH this book was originally published in 1939, there is no indication of significant revision or addition. It is a book written essentially for beginners, and tends to employ the arithmetical and empirical rather than the mathematical approach. The treatment is limited to statically-determinate structures; influence lines for structures of the indeterminate type receive no consideration whatever. The first chapters deal with influence lines for reaction, shearing force, and bending moment for a simply-supported beam, with the method of sections, and with the effect of cross girders and stringers. Later chapters are devoted to detailed consideration of the application of influence lines to the design of a bowstring girder, a plate-girder railway bridge, a light Warren-truss road bridge, a Pratt-truss road bridge, and a braced-cantilever and suspended-span road bridge. Next, two chapters are given on influence lines for the three-hinged parabolic arch rib and the three-hinged spandrel-braced arch, followed by others on the Baltimore truss and miscellaneous trusses such as the Pennsylvania or Pettit truss and the Pratt truss with double-panelled stringers. Bridge loadings and impact are then considered and the book concludes with a chapter on influence lines for deflection.

Within the limitations which the author has set himself, this is a useful book, but it shows some signs of having been prepared in haste. An erratum slip gummed to the title page aims at correcting this condition, but it is not complete. A list of abbreviations and symbols is given, but is not used consistently in the text; indeed, there are places where the author uses these symbols with quite different meanings—which can be rather more than an annoyance to the beginner, for whom the book is intended. It may be noted, too, that the chosen symbols are not in conformity with the practice recommended in British Standard No. 560. The book is illustrated by numerous line diagrams, some of which, unfortunately, are so small as hardly to be read with the naked eye. Unexpected items in the index are "Ur" and "*fratres pontifices*"; though the beginner concerned with the practical use of influence lines in bridge calculation may not find these items directly useful, they may well serve to add to his studies an interest for which he may be grateful.

Chimie Organique. Vol. I. *Chimie Organique générale*; Vol. II. *Fonctions simples.* By PROFESSOR A. KIRRMANN. Collection Armand Colin, Nos. 246 and 247. Librairie Armand Colin, 103, Boulevard Saint-Michel, Paris, Ve. [Price 100 francs each volume.]

AMONG previous volumes in the chemical section of the "Collection Armand Colin" were three on *Chimie minérale*, by Copaux and Perpérot, and one on *Chimie générale*, by Bouzat. Professor Kirrmann is about to fill a notable gap in this section with three volumes on organic chemistry, of which the first and second have now appeared. The first of these discusses in broad outline the chief problems confronting the organic chemist, and the general principles that have been developed to guide him towards their solution. While such a method of approach presupposes a certain elementary knowledge of chemistry, it does permit a more systematic presentation of the subject. The first part sketches the historical evolution of organic chemistry from the chemistry of plant and animal products to the chemistry of the vast array of synthetically prepared carbon compounds, the majority of which include hydrogen, oxygen and nitrogen, together with carbon, and fall into well-defined series. Organic chemistry, as the chemistry of radicals, is distinguished from inorganic chemistry, as the chemistry of ions, and an indication is given of its growing industrial importance, particularly in the fields of plastics and pharmaceutical preparations. The second part is devoted to the general study of organic compounds.

Before the structure of a compound can be ascertained, it must be obtained in a state of purity, generally much less readily accomplished with organic than with inorganic compounds. Then it has to be analysed to determine its empirical formula, in which connection attention is directed to the newer methods of microanalysis. The real key to the architecture of organic molecules, however, resides in their structural formulæ. These are based upon the concept of characteristic groups of atoms, or radicals, linked by valency bonds and it is shown how, by substituting one group for another in exchange reactions, it is possible to decide the way in which the groups are arranged. In discussing the theory of valency and the physical interpretation of the covalent bond, which is of major significance in organic molecules, the ideas of wave mechanics are introduced. The manner in which the phenomena of stereoisomerism, in conjunction with the hypothesis of the tetrahedral carbon atom, enabled the chemist to solve the problem of the spatial configuration of the groups, and the methods whereby the physicist has determined inter-atomic distances and bond angles, are lucidly described. An admirable summary is given of the empirical rules that have proved of great practical importance in correlating chemical constitution with physical properties. These are classified as additive properties, of which the most widely used is molecular refraction; and constitutive properties, among which the most important are likewise optical. A start has been made to provide a theoretical interpretation for certain of these empirical formulations based upon quantum theory considerations. Problems of physical equilibrium are briefly discussed and a chapter is devoted to organic colloids. The third part treats of the reactions of organic chemistry under the headings of fundamental types, chemical kinetics, intramolecular transposition and tautomerism, concluding with an account of the theory of reactions and the study of selected specific types of reaction.

The great advantage of grouping together the fundamental principles of organic chemistry and dealing with them at the outset is that the descriptive side of the subject can be presented without the usual interruptions and asides. Volume II is devoted to simple functions which Professor Kirrmann likens to the grammar of organic chemistry, since it provides the foundation for the understanding of complex functions that are to form the subject matter of volume III. The six chapters contained in this second volume are devoted, respectively, to the hydrocarbons, monovalant, divalent, trivalent and tetravalent functions, and heterocyclic compounds. Under each function the aliphatic, alicyclic and aromatic derivatives are considered in turn, the amount of space devoted to the various compounds being governed by their scientific or industrial importance. The approach throughout is experimental, typical chemical and physical properties being indicated after methods of preparation have been described.

Professor Kirrmann's introduction to the study of organic chemistry, though modest in size, is masterly alike in the logical order of its presentation and in the clear manner of its exposition. By his conspicuous success in exhibiting the material in the form of a coherent edifice rather than as a mass of factual detail, he has contributed to the "Collection Armand Colin" two volumes enhancing its high reputation and in perfect accord with its motto, *Vulgariser sans abaisser.*

Tables of the Bessel Functions of the First Kind of Orders Four, Five and Six. Tables of the Bessel Functions of the First Kind of Orders Seven, Eight and Nine. By the Staff of the Computation Laboratory of Harvard University. Harvard University Press, Cambridge 38, Massachusetts, U.S.A. [Price 10 dols. each volume]; Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 55*s.* net each volume.]

THESE two sets of tables, published simultaneously as Volumes V and VI of "The Annals of the Computation Laboratory of Harvard University," follow hard upon the heels of volumes III and IV, devoted to *Tables of the Bessel Functions of the First Kind of Orders Zero and One, Two and Three*, respectively, a notice of which appeared on page 338 of vol. 164 of ENGINEERING (1947). In a serial work, promptness of publication is a major virtue, but in a computation project of this magnitude such promptness of publication would be virtually impossible without the Automatic Sequence-Controlled Calculator. The punched control tapes conveying the operating instructions to this machine were designed by Richard M. Bloch. The method of computation is based upon the recurrence relation which enables a Bessel function of order $n+1$ to be built up from the corresponding functions of order n and $n-1$. Thus, from the values of $J_2(x)$ and $J_3(x)$, tabulated in volume IV, the corresponding values of $J_4(x)$, tabulated in volume V, are obtained from the equation $J_4(x) = \frac{6}{x} J_3(x) - J_2(x)$, and so on. Three functions are tabulated on each page to ten decimal places, the increment in the argument being 0·001 for $0 \leqslant x < 25$ and 0·01 for $25 \leqslant x < 100$.

A note on interpolation in the tables precedes the first of these volumes. The most effective method is based upon the Taylor expansion of $J_n(x) = J_n(a+h)$, wherein the derivatives are replaced by their functional equivalents. Consideration of the remainder term enables the appropriate number of terms to be included to be ascertained. Over the range $0 \leqslant x < 25$, termination of the series after three terms limits the liability of error to one unit in the tenth decimal place, while over the rest of the range the same accuracy is secured by terminating the series after four terms. Examples to illustrate the procedure are given. As in the two earlier volumes, the tabular entries are printed, after being checked, by the machine itself, and their reproduction by offset lithography practically excludes the possibility of error. Those who have to apply Bessel functions to specific problems can congratulate themselves that means and material can still be found to issue these definitive tables at such short intervals and in so handsome a form.

STEEL OUTPUT IN CANADA.—The steel ingots produced in Canada during the eleven months, January to November, 1947, totalled 2,613,467 tons (of 2,000 lb.), against 2,022,120 tons in the corresponding period of 1946.

EARLY KITSON LOCOMOTIVE: ALTONA AND KIEL RAILWAY.

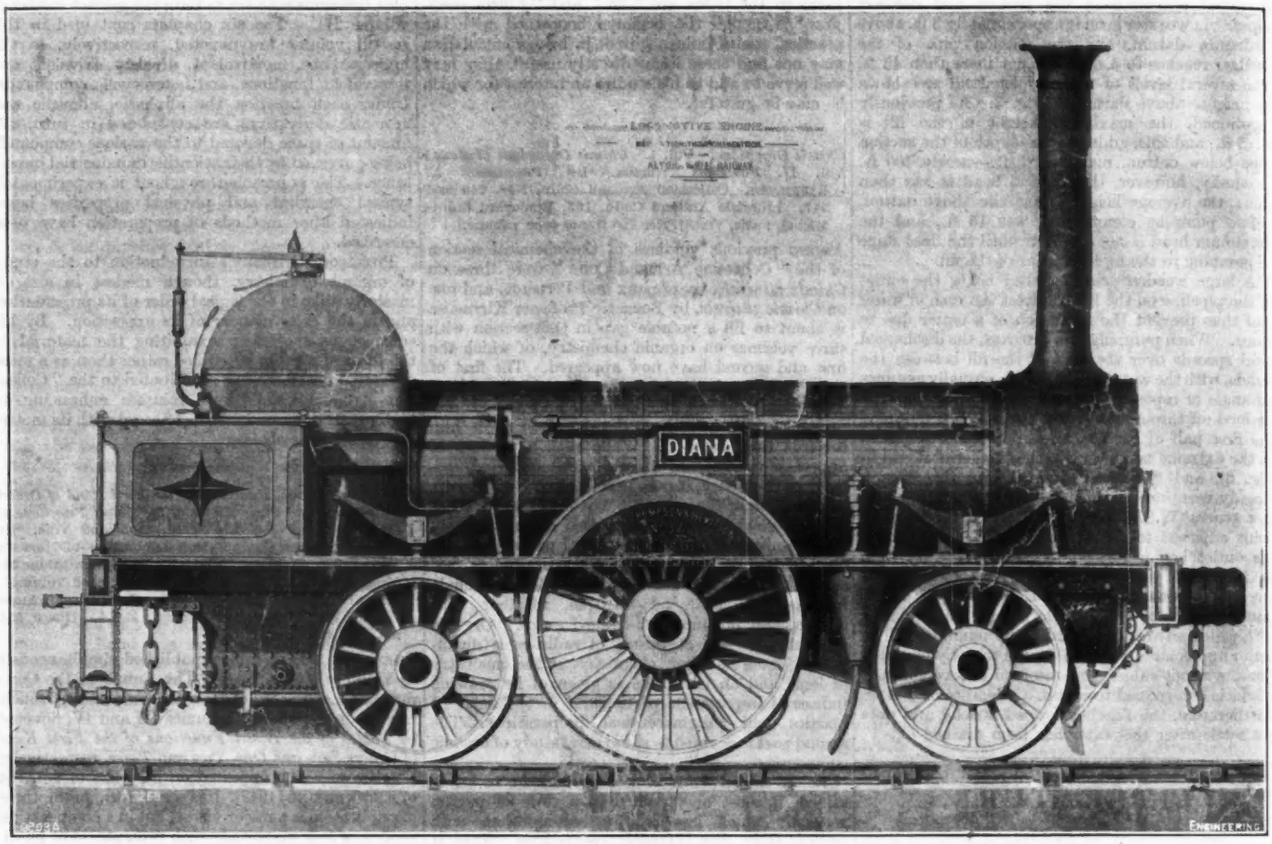


FIG 1.

AN EARLY KITSON LOCOMOTIVE.

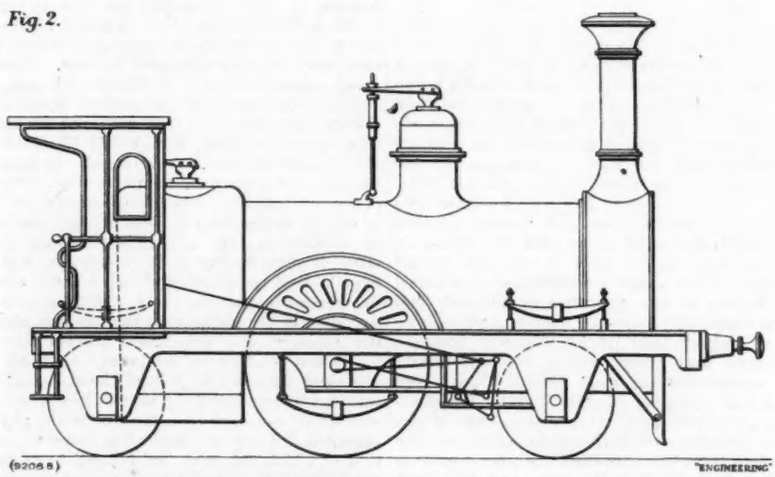
By P. C. DEWHURST, M.I.Mech.E.

WHEN on a visit to the Tegel works of Messrs. Borsig, midway between the two wars, the writer was shown, in an album of illustrations of early locomotives, a photographic copy of the "picture-drawing" reproduced in Fig. 1, herewith, which the then management were good enough to present to him. The drawing is believed to have lain in obscurity for some 80 to 90 years, so far as the British locomotive world is concerned and, for this reason, and because the locomotives which it represents were constructed over a century ago, these notes upon it may have some interest to students of railway history.

As can be seen by inspection of the reproduction, the drawing had been severely damaged before the copy was made; in fact, the piecing together of what evidently was an original drawing, much deteriorated and torn into many separate fragments, must have been the work of someone who was intensely interested in locomotives. The damaged condition of the title shows it to have been cut from the original and pasted in place for copying; it reads, "Side Elevation of LOCOMOTIVE ENGINE manufactured by Messrs. Kitson, Thompson & Hewitson for the ALTONA & KIEL RAILWAY."

The engine represented is one of five which were constructed by the firm—subsequently better known as Kitson and Company, of Leeds—in 1843-4, for the Altona-Kiel Railway; the makers' numbers were 37 to 41. A few of the principal dimensions are given below, though this article is chiefly concerned with matters other than dimensions. The cylinders were 13½ in. in diameter by 20 in. stroke; and the driving and carrying wheels were 5 ft. 4 in. and 3 ft. 6 in. in diameter, respectively, the total length of wheelbase being 10 ft. 10 in.

Fig. 2.



The boiler barrel was 11 ft. 7 11/16 in. long and slightly elliptical in section, the horizontal diameter being 3 ft. 3¾ in. and the vertical diameter 3 ft. 1¾ in. The firebox shell was 3 ft. 9¼ in. long, and the total heating surface was 753 sq. ft.

The design is a "single" of the Stephenson long-boiler type (Robert Stephenson's patent of June 23, 1841) with inside cylinders. In accordance with Kitsons' practice of that period, it follows fairly closely the Stephenson pattern of that time, including the upper portion of the firebox and the valves between the cylinders; but the valve-gear differed entirely from Stephenson's practice with this type of engine. The Kitson design also illustrates the firm's then habit of strongly connecting the leading and driving horn-plates by a full depth longitudinal plate, as well as the considerable inclination of the spring links. Sand-boxes were provided for forward running, as can be plainly seen; this must have been among the earliest examples of a fully-developed sanding system.

Although "Stephenson's Patent" is lettered in a specially prominent manner on the edge of the running plate, it is to be noted that flanges are shown upon the driving-wheel tyres, contrary to the contemporary Stephenson practice. Another noteworthy feature is the valve-gear; the reversing mechanism which appears upon the drawing seems to indicate the Dodds wedge-motion, which was then experiencing its brief spell of popularity and which was used upon two contemporary engines by Kitson and Company for the Midland Railway. Unfortunately, none of the between-frames portions of the valve-gear is shown, but it is very improbable that the

valve-gear was of the traversing-eccentric pattern, then out of date, in combination with an over-elaborate reversing gear; it is more in accord with that generally accompanying the Dodds motion. Obviously, the engine was not equipped with the four-eccentric valve-gear employed by Stephenson on this type of engine. It may be added that Theodore West, in his well-known *Diagrams of Locomotive Engines* of 1885 (Sheet II, Fig. 52), notes on the diagram representing these engines, "Dodds expanding (*sic*) wedge motion"; which may be considered conclusive, as West had been closely connected with Kitson and Company at the Airedale Foundry in its early days.

The original drawing certainly seems to have been made by the builders of the engines; the way in which the name, etc., of the firm is displayed upon the splasher would not have been adopted except upon a drawing made by the firm responsible for the construction. The manner of placing "Stephenson's Patent" upon the edge of the running-plate is also noteworthy. On the drawing, the name of the engine clearly appears as Diana, and not, as generally supposed, Dania; the latter name, however, is shown on West's sketch already mentioned. It is known, moreover, that the other engines of the batch bore the names (at any rate, at some not much later date) of nearby countries and rivers; for instance, one was named Germania. In Germany also the view was held that Dania was the name; it seems probably that it was the intention in Germany that the name should be Dania, but that Kitsons' named the locomotive Diana—perhaps by mistake.

The records of the Airedale firm show only seven 2-2-2 engines of this pattern as having been constructed by them; besides the five engines here dealt with, two, which were larger and had flangeless driving tyres, were built in 1845 for the Midland Railway. One of these caused some excitement during the Gauge Commission trials of 1845-6 by leaving the rails at speed between York and Darlington.

Although long-boiler "single" passenger engines generally had a short life in England, they lasted longer on the Continent. There must have been good material in these Altona-Kiel locomotives, as three were reconstructed in 1870, a description of them appearing in *Die Organ für die Fortschritte des Eisenbahnwesens*. It is evident from the diagram accompanying that account, shown here in Fig. 2, opposite, that the rebuilding comprised new boilers, new frames and new valve-gear. The engines were then no longer of the long-boiler pattern; nevertheless, from the specification cited in the account, it is clear that they still contained much English material. In 1880, the three engines became Nos. 1, 2 and 3 of the Prussian State Railways, and it is believed that they lasted some years beyond that date.

PUBLIC HEALTH EXHIBITION.—The centenary of the first Public Health Act in Great Britain will be celebrated at Olympia, London, W.14, from November 15 to 20, by the holding, for the first time for ten years, of the Public Health and Municipal Engineering Congress and Exhibition. The exhibits will include equipment for every branch of public service, namely, water, gas and electricity supply; drainage, sewage, street cleansing and refuse disposal; and quarrying, road-making, site preparation and municipal transport. Historical exhibits will illustrate the progress made since the Royal Assent was given to the first Public Health Act, on August 30, 1848.

LYMINGTON-YARMOUTH FERRY.—On March 4, British Railways, Southern Region, put into service on the Lymington-Yarmouth route to the Isle of Wight, the M.S. Farringdon, a new Diesel-electric passenger and motor-car ferry which has been built by Messrs. William Denny and Brothers, Dumbarton. This is the largest vessel to be employed on this service, having accommodation for 320 passengers and 32 cars, or 800 without cars, and has been built to provide for the expanding traffic, which, in 1947, was 60 per cent. higher than in 1938. The Farringdon has gangways at each end, to enable cars to be driven on and off without turning or reversing; she is provided with two wheelhouses with duplicate controls for manœuvring in either direction. A speed of 10½ knots an hour can be maintained in both directions, and two rudders are fitted at each end. The main dimensions are: length, 178 ft.; maximum breadth, 49 ft. 6 in.; draught, 6 ft.; gross tonnage, 489.

RESEARCH IN AUSTRALIA.

(*Concluded from page* 162.)

THE important department of research which deals with lubricants and bearings has been retitled the Tribophysics Division—an unfamiliar word, though one of unimpeachable derivation, from the Greek for "rubbing"—which is now intended to embrace not only engineering processes ranging from friction to machine-tool cutting, but also many related fundamental problems in chemistry and metallurgy. The Division is studying, for example, the theory of propagation of explosion in nitro-glycerine, and recently has completed a device for measuring the pressure of recoil in Army field guns. In order to explore the mechanism of boundary lubrication by surface-active compounds, friction and electron-diffraction examinations are being made on adsorbed surface layers of fatty acids, soaps, alcohols, esters and hydrocarbons. Some correlation has been discovered between the frictional properties of bulk lubricants, the friction obtained with mono-molecular and tri-molecular adsorbed layers, and the orientation of the layers. The degree of adsorption of surface-active compounds is being studied in terms of the contact angle of lubricants on metal surfaces. Compounds containing "active" chlorine, in solution in mineral oils, give good boundary lubrication, particularly on steel surfaces, as a result of the formation of an iron-chloride film. Provided that no water is present, both ferrous- and ferric-chloride films, artificially produced on steel, display excellent low-frictional properties; but, if even slight traces of moisture are present, corrosion takes place and completely destroys the lubricating qualities.

An interesting technique has been developed for estimating the extent of surface damage and metallic transfer between sliding surfaces. If one surface consists of a radio-active metal and slides over an inactive surface, the amount of metal transfer can be measured by use of a Geiger counter, or, sometimes more conveniently, by placing the previously inactive surface on a photographic plate and obtaining a "radio-autograph" of the transferred particles of radio-active metal. The technique has been applied successfully to a lead sphere sliding on lubricated and unlubricated steel, copper, and lead, and has revealed markedly different characteristics for lubricated and unlubricated sliding. In the not unrelated field of wire-drawing lubrication, an investigation of die materials, such as tungsten carbide and diamond, has disclosed that these extremely hard substances, sliding together, have exceptionally low friction even when unlubricated. Other research is proceeding to explore the properties of silicone and similarly constituted lubricants, which are distinguished by exhibiting very small changes of viscosity with temperature. One lubricant of this type has been found to operate satisfactorily over the temperature range from −40 deg. C. to +200 deg. C. So far, the work has been largely concerned with preparing such lubricants by synthesising organo-silicon polymers and determining the lubricating properties of mono-molecular surface layers. A possible connection between the known reduction of metallic friction and the recently discovered reductions of the hardness and tensile strength of metals, both caused by surface-adsorbed compounds, is the reason for a preliminary investigation of these effects, which has revealed changes of mechanical properties in non-metallic as well as in metallic surfaces and is being pursued further by tensile tests of single metallic crystals.

The potentially important discovery of thermal fatigue in metals, which takes the form of deformation in metals of non-cubic crystal structure consequent upon anisotropic thermal expansion, has now been enlarged to give information of value in the selection of bearing metals for severe service. The fact that non-cubic metals cannot be obtained in a completely undeformed condition is of significance in casting and annealing practice. A somewhat different metallurgical approach has led to the development of an X-ray method for observing the relative deformation and re-crystallisation characteristics of the two phases in 60:40 brass. This alloy is also the subject of an investigation into the wear of alloys consisting of two or more phases. The method involves taking a section at an acute angle along the track made by a spherical contact moving over a brass plate. The magnified taper section is microscopically examined at high magnification. In preparation for extending this technique to steel and cast iron, various methods of surface preparation are being examined to ensure clean metallic surfaces, so that authentic values shall be forthcoming for wearing qualities. Lapping and grinding operations have had to be rejected on the ground of contamination or deformation of the surface, and attention is turning to electrolytic polishing, for which several new reagents have been developed. Concurrently with this applied work, the fundamental principles underlying the polishing of metal surfaces by controlled dissolution of the metal in an electrolyte are being studied.

Among a number of war-time tribophysical investigations which have been completed during the year is one concerned with the relation between wear in gun barrels and the frictional heating which, when the gun is fired, causes local hardening at points in the barrel and eventually promotes wear of the barrel in service. This conclusion, derived from "static" experiments in which shells were forced under controlled conditions through the barrel of a two-pounder gun, conflicts with the theory, generally held, that the heating and hardening of the barrel are mainly caused by hot gases following the shell. The visit of H.M.S. King George V to Melbourne in 1945 provided an opportunity for some 70-ft. model skyscreens, designed in Australia for the measurement of projectile muzzle velocities, to be used for calibrating the ship's main armament at sea. A similar subsequent calibration was carried out in H.M.S. Anson in April, 1946. Other research on explosives includes experiments which have revealed that the sensitiveness of liquid explosives is enormously increased by the presence of very small quantities of occluded gas. This effect, studied with air at different pressures and gases of various specific heats, is mainly due to the adiabatic compression of tiny gas pockets, entrapped by the liquid; whence it follows that, if precautions are taken to prevent air being entrapped, sensitiveness to detonation is drastically reduced to a low value. As regards the propagation of explosion, the passage of the explosive process has been studied by the aid of a specially constructed drum camera. The result is to establish that, under suitable conditions, the explosion begins slowly, at about 400 m. per second, and then suddenly increases its rate of propagation to the region of 1,800 m. per second. In other and reproducible circumstances, the very beginning of the explosion may advance at 5,000 m. per second for a short time, and only thereafter fall suddenly to 400 m. per second and again rise to 1,800 m. per second, as before. For the continuation of similar propagation experiments with substances specifically suited to rocket propulsion, a new revolving-mirror camera with very large writing speed and high resolving power is being constructed.

In many instances, research on engineering subjects is valuably furthered by assistance in such respects as chemical analysis. The Australian research organisation includes a Division of Industrial Chemistry which not only provides such assistance to other departments, but conducts on its own part important investigations into the utilisation of Australian mineral resources. Substances within this category include chromite, graphite, fluorite and monazite (a minor component of the "black sands" of the eastern Australian beaches, which contain thorium, cerium oxide for optical-glass polishing, sparking "flints," and rare earth fluorides for searchlight carbons). A good deal of research is also concerned with the chemistry of cements, clays and moulding sands, as well as of industrial plant products and organic compounds generally. Of especial interest are attempts to develop synthetic resins of the aniline-formaldehyde type, for manufacture in Australia, and a variety of other original work on plastics. The division includes a group of chemical engineers who develop pilot plants for industrial purposes; and a bio-chemistry section interested in the chemical aspects of the animal products industries.

Research in physics, similarly, provides many examples of contributions to industrial projects. The adaptation of thermocouples, for example, as means of measuring and controlling atmospheric humidity, has found applications in the tropic-proofing of electrical equipment, while an electrical resistance moisture-content meter, developed in England at the National Physical Laboratory for use in particulate material such as bulk grain, is being further developed in Australia for measuring the moisture content of wool and other fibres. Investigations in industrial pyrometry have been concerned with the temperatures in glued joints of wooden aircraft under construction, the use and calibration of gasket thermocouples on aircraft engines, and miscellaneous techniques of surface-temperature measurement. One of the permanent functions of the Physics Division is the maintenance of temperature standards and the International Temperature Scale. In the endeavour to maintain the Scale independently of secondary standards calibrated elsewhere, the Division has improved the accuracy of its apparatus for realising the "silver" and "gold" points, while equipment has been made to permit the boiling point of oxygen to be determined. Shortly, in consequence, it should be possible to establish the International Scale from — 190 deg. C. up to + 2,300 deg. C., with sufficient accuracy for the needs of Australian standardisation. Among a variety of other thermal work, the design of apparatus for measuring thermal conductivities of insulating materials down to sub-zero temperatures, and the thermal transmission characteristics of wall structures, are noteworthy as bearing on industrial practices, especially in the field of refrigeration.

In the subject of light, physics research has been naturally concerned with a wide range of optical devices, among which one of especial interest is a means for comparing maps with the corresponding images obtained by radar from aircraft. The installation of a recording spectrophotometer, which automatically indicates the spectral transmission or reflectance of materials like paint, paper and textiles, is likely to prove valuable to those industries as well as to dyeing technologists. The same is the case with a photoelectric tricolorimeter which is being modified in certain respects to make it more suitable for industrial use. Other work is in progress on instruments for the measurement of hæmoglobin concentration in blood, and for the appraisal of gloss on the surfaces of manufactured decorative articles.

On behalf of other industries, techniques have been improved for the X-ray diffraction investigation of metals, refractories and biological substances. Textiles, more particularly wool fibres, figure so prominently among the last that the study of wool problems now covers such questions as the measurement of fibre diameter and the frictional properties of textile fibres generally. The most promising instrument so far developed for fibre diameter consists of a photometer which measures the light intercepted by a group of teased-out fibres. The result is combined with the weight of the fibres to give a measure of their mean diameter. The work on fibre friction is providing information about the mechanism of shrinking and felting, and, incidentally, has revealed the very interesting facts that the wool fibre exhibits two principal coefficients of friction, for movements respectively towards and away from the root end of the fibre; and that the difference between them is the initiating cause of the tangling which is wool felting. The effect of shrinkage-reduction treatments is to reduce the difference between the two frictional coefficients. A related discovery is that exceptionally clean wool has a quite different frictional behaviour from ordinary wool, largely because of the film of oil and grease on the latter.

Physics of less immediate industrial importance, but of great potential scientific value, has been concerned since the war with problems of radio-wave propagation at ultra-high frequencies, such that the relevant phenomena are markedly affected by the properties of the lower atmosphere. This "super-refraction," as it is termed, produces two effects of special importance to Australia. One is the radiation inversion which occurs over a land mass at night. The other is the coastal "front," which exists during the summer over most of the coast of Australia south of latitude 30 deg. and is particularly noticeable over the coast of New South Wales. The coastal front not only influences radio propagation, but appears also to be the major meteorological factor influencing Australian summer weather in coastal regions, where it is believed to extend many hundred miles out to sea. Data accumulated during the later war years suggest that super-refraction is more frequent and intense than in England, and that many different factors are involved. Experimental research is to be conducted with a variety of appropriate apparatus, facilitated by an aeroplane and a flying-boat. Radar sets operating on wavelengths of 3 cm. and 10 cm. are already being used for meteorological forecasting of raineclouds and storms, and more fundamental research is in hand on the main problem of micro-wave scattering by water drops, which is intended, eventually, to be used for studying cloud structure, atmospheric air movements and turbulence, and other meteorological phenomena.

Concurrently, work is proceeding on the association between solar noise and sunspot activity. On a receiving frequency of 200 megacycles per second, three distinct phenomena have been distinguished. The first is a steady excess-noise level, attributed to thermal radiations from the sun's corona at temperatures of the order of a million degrees absolute. The second is the appearance of short bursts of noise at an intensity which indicates their origin in electrical discharges, probably associated with solar flares or corona prominences. Finally, there is the general increase in noise level ascribed to sunspot activity, also possibly originating in electrical discharges. It is of interest to remark that similar noise phenomena can be detected by radar, from sources in galaxies in other parts of the universe. Along with such important fundamental studies, the practical applications of radar are being actively pursued in connection with aircraft operation and aerial surveying; for example, a distance indicator has been designed whereby a pilot may read off the distance of his aircraft from a selected point or airport. Another proposal, which has been worked out, is for a multiple-track pulsed radar range, radiating from a central point and largely independent of the topography of the site. The Department of Civil Aviation is co-operating in testing the idea, but no large-scale installation will be made in Australia until international agreement has been reached on the future form of this type of aircraft navigational aid. The programme of work on radar aids to surveying includes observations of the precision with which small time intervals can be measured under various atmospheric conditions. Already the distance from the laboratory to a beacon 50 miles away can be measured by this technique to within two yards, and further improvement is expected to reduce the error to within one foot.

The precise electronic work of the sort carried out by the Radiophysics Division depends a good deal on the maintenance of frequency standards. Experiments are in progress to improve the relations between measurements at very high frequencies and the fundamental electrical and metrological standards, so as to establish a series of equipments for measuring impedance, power, frequency and associated quantities throughout the frequency spectrum in practical use. Initial attention is being directed to the range from 20 to 200 megacycles per second, which will increase in importance with the development of television and frequency-modulated transmission in Australia. Frequency standards are to be supplied by the British Post Office. Pending their receipt, a constant-frequency generator with a stability of one part in a million has been set up for experimental use. Other electrotechnical research, of more immediate application to industry, has been concerned with the treatment of glass and ceramic surfaces to give improved electrical properties. One result already established is that surface-active amines can greatly increase the surface leakage resistance of both glass and ceramic insulators exposed to high humidities. In the more mechanical aspects of standardisation, the Division of Metrology has determined the coefficients of thermal expansion of Invar surveying tapes over a range of 30 deg. C. by the ingenious expedient of heating them by the passage of electric current, and observing the temperature distribution with thermocouples. Special attention is directed in this division to the standardisation and periodical calibration of industrial testing machines by means of portable equipment.

The research activities briefly outlined in the foregoing paragraphs relate specifically to subjects within the broad category of mechanical physics, selected for their interest to engineers or their potential bearing on engineering progress. It must be realised, however, that the work fostered by the Australian Council for Scientific and Industrial Research also embraces a vast amount of research upon agricultural and similar subjects. Plants, animals, insects, pests, soils, fish, food preservation and dairying are all covered by carefully organised programmes of research in which matters of urgency to the progress of lucrative Australian industries are being studied, while, at the same time, the fundamental science underlying each of them is being steadily advanced. Merely to consider the range of the subject-matter of the Report is to realise what an amount of scientific work is being done in the Commonwealth, relative to its population. From the standpoint of the advance of technical knowledge, moreover, the Report is an impressive document, while the style and presentation of the textual material are exemplary and reflect great credit on all responsible for its compilation. It is assured of the keen interest and close attention of technical men throughout the English-speaking world for the optimistic picture it gives of progress in Australia as well as, inherently, for the new information, much of which is here published in convenient collected form for the first time.

ELECTRICITY SUPPLY IN ECCLES.

A PUBLIC supply of electricity was first given in Eccles, Lancashire, on December 14, 1898. The jubilee of this event has been celebrated this week, however, the anticipation of the anniversary being possibly due to the change in ownership which will take place next month. The original generating station was situated in Cawdor-street and was initially equipped with two 120-kW steam-driven alternators from which a supply was given at 200 volts on the single-phase system. Extensions to this plant took place from time to time and by 1911 the total capacity had increased to 1,325 kW. Thereafter, however, the increasing demands of industrial consumers led to a supplementary three-phase supply at 6,600 volts being obtained from the Lancashire Electric Power Company, while in 1928 all the requirements of the undertaking were drawn from the same source when the Cawdor-street station was closed.

At the present time the supply is normally obtained on the three-phase system at 33 kV from the Barton station of the Manchester Corporation through duplicate underground mains, which are looped into a receiving station in Mount-street. These mains then continue northward to the Kearsley station of the Lancashire Electric Power Company, from which an alternative supply is therefore obtainable. The aggregate capacity of the transformers in the Mount-street receiving station is 20,000 kVA, and a second station, with a capacity of 12,000 kVA, is being erected at Green-lane, Patricroft. This station will be linked by a 33-kV underground ring main with that at Mount-street and also with Barton and Kearsley generating stations. The incoming 33-kV supply is stepped down to 6·6 kV and power is distributed at that pressure to 60 sub-stations in various parts of the borough, while from the latter a low-tension supply at 400/230 volts is given to all classes of consumer. Between 1929 and 1939 the original single-phase system of distribution was converted to three-phase, the cost being borne entirely out of revenue or reserve. The electricity sold during the year ended March 31, 1947, amounted to 34,536,983 kWh, of which nearly half were supplied for power purposes. It is interesting to record that during the year ended March 31, 1900, which was the first complete twelve months of operation, the amount sold was 130,905 kWh. The present borough electrical engineer is Mr. C. V. Johnson.

BICYCLE AND MOTOR CYCLE SHOW, EARL'S COURT.—The British Cycle and Motor Cycle Manufacturers' and Traders' Union are organising the first Bicycle and Motor Cycle Show to be held since 1938. It will take place at Earl's Court, London, S.W.5, from November 18 to 24.

WATER-TUBE BOILERS AT CLYDE'S MILL POWER STATION.

In a paper on "Water-Tube Boilers," delivered on December 12, 1947, at a meeting in Glasgow of the Scottish Engineering Students' Association, Mr. E. G. Yarrow, M.B.E., included a description of the Yarrow boilers installed during the war in the Clyde's Mill power station of the Clyde Valley Electrical Power Company and gave the results of the official trials of one of the boilers, carried out after it had been steaming continuously for 14 months. The particulars given below are summarised from Mr. Yarrow's paper.

There are eight boilers, of the Yarrow S.F.3 type, each having a normal evaporation of 80,000 lb. per hour and a maximum continuous rating of 100,000 lb. The working pressure and steam temperature at the superheater outlet are 400 lb. per square inch and 785 deg. F., respectively. The temperature of the feed water entering the economiser is 250 deg. F., and the temperature of the flue gases at the air-heater outlet, at normal load, is 275 deg. F. The guaranteed overall thermal efficiency, based on the gross calorific value of the fuel, is 84·5 per cent. at normal load and 83·0 per cent. at the maximum continuous rating. The boilers are housed in a separate building, at right angles to the turbine room, and are arranged in two rows of four each, with a central firing aisle. Each boiler is a self-contained unit with its own superheater, economiser, air heater and draught plant. Each boiler has a generating-tube heating surface of 8,980 sq. ft. and a water-wall surface of 366 sq. ft. The single steam drum is 50 in. in diameter and the three water drums are 23 in. in diameter. All drums are seamless, hollow-forged with riveted ends. The tubes in the front and rear banks are 2 in. outside diameter and in the centre bank, 2½ in. outside diameter. The majority of the tubes are straight, and all are expanded directly into the drums. A manhole is provided at each end of each drum. Allowance is made for expansion and contraction by supporting the steam drum in cradles carried by the steel supporting structure; thus the tubes and water drums, being suspended from the steam drum, are free to move up or down. The combustion-chamber side walls are lined with Yarrow water walls, consisting of bare tubes expanded into top and bottom headers and connected to the saturated-steam drum by downcomer and upriser pipes.

Each boiler has a Yarrow self-draining superheater with a heating surface of 3,500 sq. ft. The superheater drum is of hollow-forged seamless construction, 27 in. in diameter, with riveted ends, and the U-shaped superheater tubes, 1¼ in. outside diameter, are expanded into the superheater drum. A plate baffle is fixed below the steam drum to enable the final superheat temperature to be adjusted. The economiser and air-heater are located behind the boiler. Each boiler is fitted with a flash-welded mild-steel tubular economiser of Babcock and Wilcox manufacture, with a heating surface of 4,780 sq. ft.; and a an air heater of the Yarrow tubular type, with a heating surface of 15,000 sq. ft. with tubes 2¾ in. outside diameter, expanded into steel tube-plates at the top and bottom. The gases flow upwards through the tubes and the air enters the top of the heater between the banks and makes a number of passes across the tubes. At low loads, recirculation of air raises the temperature of the air entering the heater by 25 deg. F. Each boiler has a Style 28 Babcock and Wilcox travelling-grate stoker, 18 ft. long by 16 ft. 6 in. wide. The grates are driven by electric motors through eight-speed gearboxes which give a grate-speed variation from 13 ft. to 65 ft. per hour.

The induced-draught and forced-draught fans are arranged above the boilers in a totally-enclosed fan room, the gases from the induced-draught fans being discharged into individual chimneys. Each boiler has a forced-draught fan and an induced-draught fan, supplied by Messrs. James Howden and Company (Land), Limited, and a secondary-air fan by Messrs. Davidson and Company, Limited. The forced-draught fan has a capacity of 49,000 cub. ft. per minute with a static pressure of 6·8 in. water gauge; and the induced-draught fan has a capacity of 72,000 cub. ft. per minute at a static pressure of 4·9 in. water gauge. The fans are driven by constant-speed squirrel-cage induction motors through hydraulic couplings, with remote speed control at firing-floor level. The secondary-air fan is located in the basement beneath the economiser. This fan draws air from the main hot-air duct and discharges through nozzles in the front and rear furnace walls, and is driven by a constant-speed fan-cooled motor through a flexible coupling. The induced-draught fan is fitted with a double scroll-type Howden grit collector, placed on the suction side.

Each boiler, economiser and air-heater has a complete set of Clyde soot-blowers, comprising nine single-nozzle blowers on the boiler and three on the superheater, three single-nozzle and three dual-nozzle blowers on the economiser, and two dual-nozzle blowers on the air-heater. The boiler and superheater soot-blowers are controlled by automatic electrically-operated gear.

The coal bunkers are located above the central aisle and are supplied with coal from the external coal-handling plant by means of duplicate gravity bucket conveyors. Ash and riddlings are discharged from hoppers located in the basement into portable crushing machines, which deliver to an ash suction plant. The first four boilers were in operation in March, 1944, and the complete installation was handed over to the Clyde Valley Company in February, 1945.

Date of Test.	March 27, 1945. Normal Rating.	March 28, 1945. Maximum Continuous Rating.
Nominal evaporation, lb. per hr.	80,000	100,000
Actual evaporation, lb. per hr.	83,442	101,869
Pressure at superheater outlet, lb. per sq. in.	395	395
Final steam temperature at superheater outlet, deg. F.	784·3	794·5
Temperature of water entering economiser, deg. F.	247	245·5
Temperature of water leaving economiser, deg. F.	339	341
Temperature of gases leaving boiler, deg. F.	590	625
Temperature of gases leaving economiser, deg. F.	361	383
Temperature of gases leaving air heater, deg. F.	257	276
Temperature of air entering air heater, deg. F.	104	118
Temperature of air leaving air heater, deg. F.	240	259
Thickness of fire, in.	4·75	5·75
Coal burned, lb. per hr.	10,425	13,225
Evaporation per lb. of coal, lb.	8	7·7
Calorific value of coal as fired, B.Th.U. per lb.	10,684	10,581
Fixed carbon, per cent.	43·60	43·78
Volatile matter, per cent.	30·93	29·78
Ash, per cent.	10·72	11·01
Moisture, per cent.	14·75	15·43
Hydrogen, per cent.	4·03	4·0
Ash produced, lb. per hr.	954	1,323
Combustible in ash, per cent.	6·6	6·78
Fine ashes produced, lb. per hr.	28·8	25·0
Combustible in fine ashes, per cent.	7·86	11·2
Riddlings produced, lb. per	7·9	9·4
Combustible in riddlings, per cent.	16·97	12·91
Grit in last boiler pass, lb. per hr.	16·6	52·6
Combustible in above grit, per cent.	34	47·7
Grit in air-heater, lb. per hr.	12·5	0·875
Combustible in above grit, per cent.	23·6	27·5
Grit in secondary collector, lb. per hr.	37·6	33·1
Combustible in above grit, per cent.	20·0	29·6
CO_2 at boiler outlet, per cent.	14·52	15·13
CO_2 at air-heater outlet, per cent.	12·68	13·92
Combustion chamber suction, in. w.g.	0·042	0·031
Gas suction at boiler outlet, in. w.g.	0·8	1·0
Gas suction at economiser outlet, in. w.g.	1·22	1·6
Gas suction at air-heater outlet, in. w.g.	1·63	2·1
Air-pressure at forced-draught fan discharge, in. w.g.	2·5	2·8
Air pressure under grate, in. w.g.	1·45	1·53
Secondary air-pressure:		
Front, in. w.g.	5·83	7·7
Rear, in. w.g.	4·2	5·5
Power consumption of auxiliaries:		
Induced-draught fan, kW	39·50	53·35
Forced-draught fan, kW	28·73	34·18
Secondary-air fan, kW	24·97	26·85
Stoker, kW	1·13	1·42
B.Th.U., feed to final steam, per lb.	1,190·8	1,197·8
B.Th.U., in economiser, per lb.	94·5	97·6
B.Th.U., in boiler, per lb.	894·6	892·7
B.Th.U., in superheater, per lb.	201·7	207·5
Gross overall thermal efficiency, per cent.	89·21	87·20
Heat absorbed by auxiliaries, calculated at 15,500 B.Th.U. per kWh., per cent.	1·31	1·28
Net overall thermal efficiency, per cent.	87·90	85·92
Efficiency guaranteed, per cent.	84·5	83·0

Heat Balance:	March 27.		March 28.	
	B.Th.U.	Per cent.	B.Th.U.	Per cent.
Absorbed in boiler	9,531·2	89·21	9,226·6	87·20
Lost in dry products of combustion	300·2	2·81	344·9	3·26
Lost in excess air	129·3	1·21	105·8	1·00
Lost in moisture in coal	163·5	1·53	173·5	1·64
Lost in moisture from combustion	401·7	3·76	404·2	3·82
Lost in combustible in ash, riddlings and grit	115·4	1·08	141·8	1·34
Radiation and unaccounted losses	42·7	0·40	184·2	1·74
	10,684·0	100·00	10,581·0	100·00

Official trials were conducted on one of the boiler units. They consisted of two tests, each of six hours duration, at normal and maximum continuous rating, respectively; the results are tabulated above. The selected unit had steamed for 14 months prior to the test, the only cleaning during this period, other than regular shift operation of the soot blower, being rough cleaning of the centre bank of tubes. The soot-blowers were used before and after, but not during, the tests.

CANADIAN PAPER MANUFACTURE.—During the period January to November, 1947, newsprint-paper production in Canada totalled 4,077,864 tons, as compared with 3,801,441 tons in the corresponding eleven-month period of 1946.

ANNUALS AND REFERENCE BOOKS.

Manual of Electrical Undertakings.—The publication of the 1947-48 edition of the *Manual of Electrical Undertakings*, more familiarly known as *Garcke*, marks the end of an epoch. The *Manual* first appeared in 1896 when it contained particulars of 79 electricity supply undertakings; since then it has kept in step with the progress of the industry by giving technical and economic information regarding the various bodies concerned. Its utility and accuracy, under the editorship of Mr. F. C. Garrett, has seldom, if ever, been questioned. With the coming of the British Electricity Authority and the winding up of the existing undertakings, whether publicly or privately owned, the arrangement will have to be changed; and although the present manual conforms to the pattern of all its predecessors the next in the series must inevitably be different, although we feel sure it will be none the less useful. The 1947-48 edition deals fully with the new organisation and includes the names of the chief officials of the Central Authority and of the various Area Boards as far as these were known at the time of going to press. It also includes a large amount of statistical data relating to recent progress and, as usual, full details of individual supply and manufacturing undertakings, with a directory of directors and officials. The publishers are the Electrical Press, Limited, 23, Great Queen-street, London, W.C.2, and the price is 3*l.* 3*s.*

The S.I.M.A. Handbook.—The 1947 edition of the Handbook of the Scientific Instrument Manufacturers' Association of Great Britain, Limited, has been issued recently. It first explains the aims and organisation of the Association, and then deals with the growth of the scientific-instrument making industry in an article by Mr. R. S. Whipple. This is followed by sections illustrating and describing briefly the manufacture of optical instruments, surveying instruments, industrial precision instruments, laboratory apparatus, ophthalmic lenses and electronic instruments. Mr. A. J. Philpot has contributed an article on the British Scientific Instrument Research Association, and a list of British research organisations is included. The greater part of the Handbook, however, is occupied by a directory of the members of the Association in alphabetical order, a classified index to the products of these firms, and a list of member firms mentioning their principal products, one page being allocated to each firm. The *Handbook*, which is bound in paper-covered boards, is obtainable, price 10*s.* 6*d.*, post free, from the Association's offices at 26, Russell-square, London, W.C.1.

The Ulster Year Book, 1947.—Among the many inconveniences arising from the recent war has been the non-appearance of a number of periodical works of reference. One that will be welcomed particularly, now that its publication has been resumed, is the *Ulster Year Book*, the previous issue of which was dated 1938. It is divided into 17 sections, dealing with the physiography, government, industries, transport, etc., of Northern Ireland; statistics of population, production, finance, etc.; the various social services, the history, and the relevant official publications in which may be found fuller details of the information abstracted, much of which is also presented in graphical form. By way of introduction, there is an admirable historical survey, by Dr. D. A. Chart, I.S.O., Deputy-Keeper of the Records, of the part played by Northern Ireland in the war. The statistical summary which follows gives the statistics for each year from 1936 to 1945, inclusive. The *Year Book* is published by H.M. Stationery Office, on behalf of the Government of Northern Ireland, at the price of 2*s.* net.

Whitaker's Almanack, 1948.—The 1948 issue of *Whitaker* is the 80th volume in a series which, to those fortunate enough to have access to a complete file, provides an unequalled survey of social, political and industrial changes in the history of Britain and the British Commonwealth—and, indeed, of the world in general. In the present volume, to quote the preface, "the dissolution of the Indian Empire, whose history has been chronicled in these pages for seventy years, and the secession of Burma from the British Commonwealth, have necessitated radical revisions"; the daily meteorological observations have been restored after an interval of nine years; national insurance has received detailed attention, and a number of the familiar sections have been revised and expanded; and (to quote the preface again), "with a boldness which, were it not reinforced by high authority, might be judged temerity, the Editor has printed a list of the Chiefs of the Names and Clans of Scotland"—which certainly should appeal to many members of the engineering profession and industry. As in previous years, the 1948 *Whitaker* is available in three styles: the library edition, bound in leather and with 13 maps, which is priced at 25*s.*; the complete edition, in cloth, which contains the same text as the library edition, but is without the maps, at 12*s.* 6*d.*; and the shorter paper-covered edition, at 7*s.* 6*d.* All prices are net. The office of publication is at 13, Bedford-square, London, W.C.1.

OIL-ENGINED MINING LOCOMOTIVE.

MESSRS. RUSTON AND HORNSBY, LIMITED, LINCOLN.

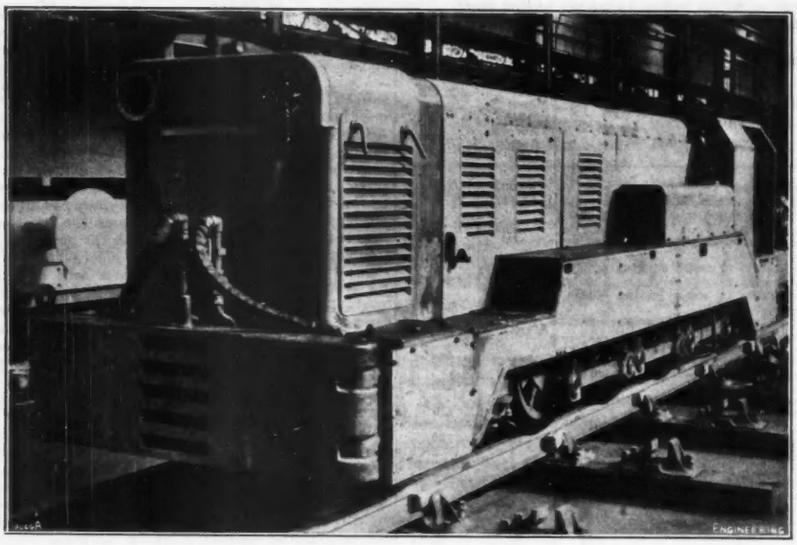


FIG. 1. LOCOMOTIVE ON TEST TRACK.

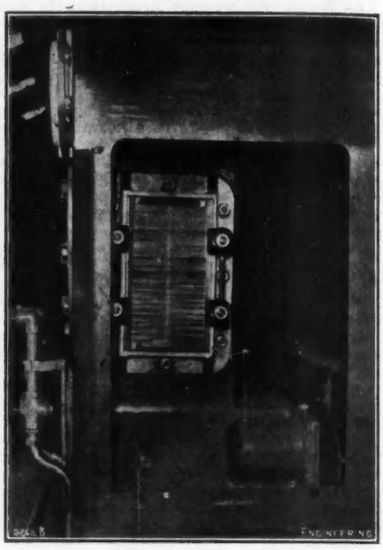


FIG. 2. EXHAUST FLAME TRAP.

100-B.H.P. MINING LOCOMOTIVE.

THERE is little doubt that the use of Diesel locomotive haulage in British coal mines will be extended considerably in the near future. The adoption of locomotives in existing coal mines, however, is limited in some cases by the heavy gradients in the roadways and the tendency, therefore, is to produce heavier and more powerful locomotives to meet these conditions. The latest mines-type locomotive produced by Messrs. Ruston and Hornsby, Limited, Lincoln, is fitted with a Diesel engine capable of developing 100 brake horsepower, which is double that of their previous most powerful type. The locomotive, which has been designated the Mark 100 DLG, is illustrated in Fig. 1, above, and in Figs. 5, 6 and 7, opposite, from which it will be seen that it is a six-coupled engine of exceptionally compact design. The locomotive is available for three different gauges, namely, 2 ft. 6 in., 3 ft., and 3 ft. 6 in., but in each case the overall width remains constant at 5 ft., while the overall height and length are 5 ft. 3 in. and 18 ft. 7 in., respectively. The weight in working order is 15 tons, so that with a moderately close sleeper spacing, the locomotive can be operated on 50-lb. rails. The wheelbase, however, is 5 ft. 10 in. and this, together with the narrow gauge, means that the minimum curve that it can negotiate is of 80-ft. radius, thus limiting its use to main haulage ways. The engine is fitted with flame traps on both the induction and exhaust systems and, in addition, an exhaust-gas conditioner is fitted thus enabling the locomotive to be used in gassy mines.

The motive unit, which has been designed and manufactured by Messrs. Ruston and Hornsby, is a six-cylinder, vertical-type, compression-ignition oil engine having a bore and stroke of 4½ in. and 5½ in., respectively. It develops a maximum of 100 brake horsepower at 1,500 r.p.m. and a piston speed of 1,375 ft. per minute, while the brake mean effective pressure at maximum rating is 100 lb. per square inch. The bedplate and combined cylinder block and crankcase are separate iron castings, the crankshaft bearings being fitted to the bedplate and secured thereto by steel bearing caps. The crankcase is provided with inspection doors so as to give easy access to the main and connecting-rod bearings and the cylinder block is fitted with renewable wet-type nitrogen-hardened cast-iron liners. The cylinder heads are separate castings and are fitted with overhead valves operated in the usual manner by rocking levers and push rods, the camshaft being gear driven from the coupling end of the crankshaft. The crankshaft is a solid-steel forging and is carried in seven white-metal lined bearings; it is drilled for bottom-end lubrication, the lubricant being supplied by a submerged gear-type pump driven through gears from the camshaft. The connecting rods are steel stampings and are fitted with steel-backed, white-metal lined bottom-end bearings and phosphor-bronze top-end bearings. The pistons are of aluminium alloy and are provided with three pressure rings and one scraper ring; the gudgeon pins are of the fully-floating pattern.

Fig. 3. SECTION AA (Fig. 4.)

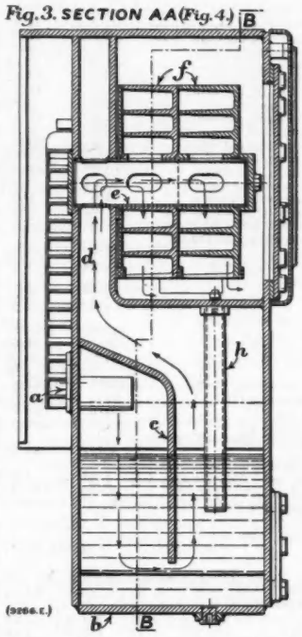
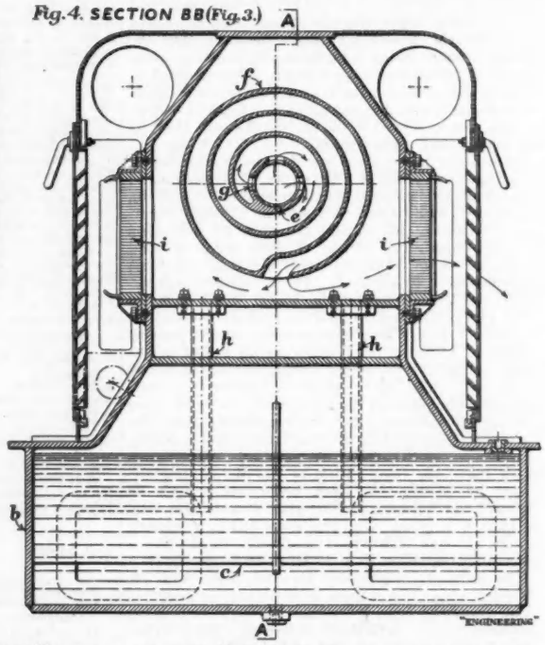


Fig. 4. SECTION BB (Fig. 3.)



The fuel-injection pump is of the monobloc type, there being a separate pumping unit for each cylinder. The metering plungers are operated by cams and the fuel delivery is regulated by helical ports formed in the plunger barrels, the barrels being rotated by a rack-and-pinion gear in the usual manner; maximum delivery of the fuel pump is controlled by a centrifugal governor fitted to the end of the camshaft. The fuel injectors are fitted with edge-type filters and a further fuel filter, provided with a renewable element, is fitted to the suction side of the pump.

Radiator cooling is employed in conjunction with a fan driven from the forward end of the crankshaft, and cooling is assisted by a belt-driven centrifugal pump. The exhaust manifold also is water cooled and the temperature of the complete cooling system is regulated by a thermostat. The engine is started by a compressed-air starter motor fitted with a Bendix pinion which engages with teeth formed on the periphery of the flywheel. Air for this service is provided by a compressor which is belt-driven from the crankshaft, the air being stored in a reservoir at a pressure of 100 lb. per square inch, but cranking gear is fitted so that the engine may be started by hand.

The drive from the engine is transmitted through a scoop-controlled fluid coupling to an S.S.S. Powerflow gearbox which is arranged to drive a transverse jackshaft at the rear of the locomotive. The jackshaft is fitted with a crank arm at each end and the drive is transmitted to the locomotive wheels through blade-and-fork coupling rods. The scoop-controlled fluid coupling was designed and manufactured by Messrs. Hydraulic Coupling and Engineering Company, Limited, Isleworth, Middlesex, and, in general, is similar to that described in ENGINEERING, on page 33, *ante*. The quick-emptying valves, however, are not controlled by the scoop, but are kept open by springs and are closed by centrifugal force at a predetermined speed, regardless of the position of the scoop. When the engine is accelerated, the quick-emptying valves are closed and the coupling is filled with the working fluid by means of the scoop, thus enabling the drive to be transmitted to the gearbox. Apart from giving a smooth start under heavy loads and obviating the need for a friction traction clutch, the fluid coupling enables the starting tractive effort to be increased momentarily, because the torque due to flywheel effect is added to the torque of the engine. Furthermore, once the speed of the engine falls below a predetermined amount, the action of the quick-emptying valves

OIL-ENGINED MINING LOCOMOTIVE.

MESSRS. RUSTON AND HORNSBY, LIMITED, LINCOLN.

Fig. 5. SECTION C C (Fig. 7)

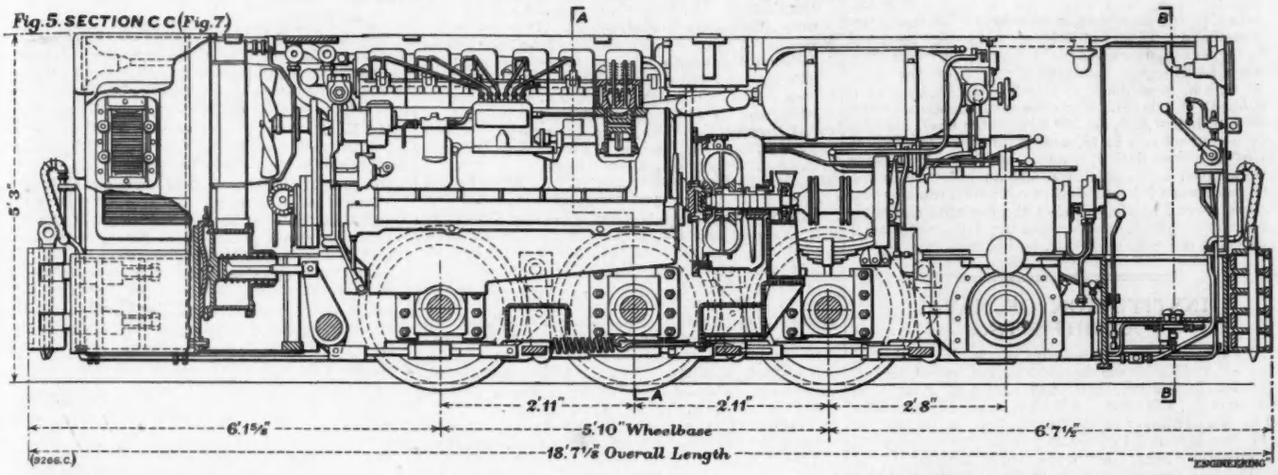


Fig. 6. SECTION AA (Fig. 5)

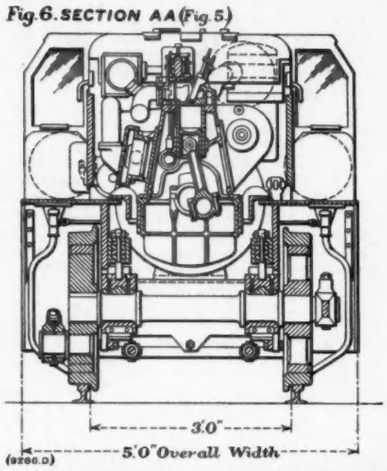
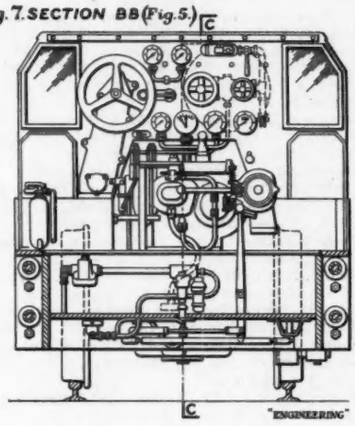


Fig. 7. SECTION BB (Fig. 5.)



ensures that the engine is isolated automatically from the transmission, thus making it impossible for the locomotive to creep forward when the engine is idling. Another advantage gained by fitting the fluid coupling is that it is impossible for the engine to be started in the reverse direction in the event of the locomotive running backwards down a gradient with the engine stalled. This is due to the fact that the half coupling fitted to the engine crankshaft must be rotated at the predetermined minimum revolutions before the coupling can function; until this occurs, the quick-emptying valves remain open and any fluid circulated within the coupling by the rotation of the output shaft automatically escapes through the quick-emptying valves.

As previously mentioned, an S.S.S. Powerflow gearbox is fitted; like the coupling, the gearbox has been designed by Messrs. Hydraulic Coupling and Engineering Company, Limited, but was constructed under licence by Messrs. Bostock and Bramley, Limited, Stalybridge, Cheshire. The letters S.S.S. are abbreviations for the words synchro-self-shifting, while the term Power-flow refers to the fact that the torque from the engine to the driving wheels is maintained during gear changes. The gearbox fitted to the Ruston and Hornsby locomotive gives three speeds in both forward and reverse directions, the speed ranges being 2 to 4¼ miles an hour in first gear, 3¼ to 8 miles an hour in second gear, and 5¾ to 12½ miles an hour in third gear. First and second speeds are obtained through constant-mesh helical gear wheels which are engaged by the action of synchro-clutches splined to the output shaft, while third speed, which is direct drive, is obtained by the engagement of an air-actuated clutch. The gearbox has been rendered self-changing by using the inherent axial thrust present in the helical gear wheels to move the synchro couplings, while continuity of torque has been obtained by arranging for momentary engagement of the air-operated clutch during the brief intervals of gear changing. Gear changing is exceptionally simple and is accomplished by the manipulation of a single lever.

The drive from the output shaft of the gearbox is transmitted to a reduction gear, the driven member of which is integral with a bevel gear. This transfers the drive to a further bevel wheel splined to a cross-shaft incorporated in the gearbox, and the drive is transferred to the jackshaft through a gearwheel and pinion, the gear wheel being keyed to the jackshaft. As previously mentioned, the jackshaft is fitted with a crank arm at each end, which transmit the drive to the locomotive wheels through blade-and-fork coupling rods. The wheels are of composite construction, having cast-iron centres with shrunk-on steel tyres, and they are pressed on to and keyed to the axles. The axles run in bronze bearings, the housings for which are located in slots formed in the main frame side members. The axleboxes are located inside the frame and the weight of the locomotive is transferred to the axleboxes through semi-elliptical springs in the usual manner; this arrangement can be seen in Figs. 5 and 6, on this page. The frame is of all-welded construction, the side members having a thickness of 1 in. Two box-section cross members are fitted and the frame is further reinforced by gusset plates at each end.

As previously mentioned, the engine is of flameproof construction throughout and both the induction and exhaust systems are provided with flame traps. In addition, an exhaust-gas conditioner is fitted to the exhaust system for although the gases are not dangerous, they can cause acute discomfort to the nose, throat and eyes of a man exposed to them. The flame traps fitted to the inlet and exhaust are of the same type and consist of grilles built up from flat stainless-steel plates held 0·016 in. apart, arranged so that the gases impinge on the edges of the plates and flow between them. The plates are fitted into frames which can be removed easily for cleaning and, to permit continuous operation, two spare flame-trap assemblies are provided. One flame trap is fitted to the induction system and two to the exhaust system, the latter being disposed one on each side of the conditioner. The conditioner is located at the front of the locomotive and extends across its full width; it is illustrated diagrammatically in Figs. 3 and 4, opposite, which show longitudinal and transverse sections, respectively. It differs radically from the conditioners previously fitted to Ruston and Hornsby mines-type locomotives, in that the gases pass through the water instead of merely impinging on it, and has been patented. After passing through the water-cooled exhaust manifold, the gases enter the conditioner through the port lettered *a* in Fig. 3, and are deflected through the water contained in the chamber *b* by the plate *c*. The cooled gases then rise through the duct *d*, which is located at the back of the conditioner, and enter the hollow spigot *e*. The spigot *e* supports two spiral chambers *f* and the gases enter these chambers by the ports *g*. The spiral chambers impart a centrifugal motion to the gases, thus further cleaning them and at the same time removing the major portion of the water vapour, the water returning to the chamber *b* by the two pipes *h*. The gases leave the conditioner through the two flame traps *i*; an external view of one of the flame traps and the upper portion of the conditioner is given in Fig. 2, opposite. The engine-cooling radiator is immediately behind the conditioner and the fan is arranged so that it delivers forwards through the radiator and thus assists in dispersing the gases. The conditioner is constructed from non-corrosive metal and is a self-contained unit which can be removed from the locomotive with comparative ease. The front buffer beam is hinged so that it can be swung to one side to give access to the lower part of the conditioner.

In the description of the transmission, it was pointed out that it is virtually impossible for the engine to be run in reverse should the locomotive coast backwards down an incline. The possibility of water from the conditioner entering the engine, therefore, are remote; nevertheless, arrangements have been made to prevent this occurring in the unlikely event of the engine running in reverse due to some other cause, such as a "kick back" when starting. This has been accomplished by connecting the exhaust and inlet manifolds to each other by a pipe in which a non-return valve is fitted. Under normal running conditions, this valve remains closed, but if there is any tendency for the engine to inhale through the exhaust system, the valve opens and automatically connects the exhaust to the inlet manifold.

The equipment of the locomotive includes a flameproof direct electric-lighting system, there being two headlamps at each end. Foot-controlled, air-operated sanding gear is provided, and this is arranged for sanding the rails in both directions of travel. Westinghouse two-line air-pressure braking equipment is fitted, which operates the brakes on both the train and the locomotive; should any portion of the train break away, the brakes are applied automatically to both the locomotive and the separated portion of the train. The buffer beams are of the multi-slot type and are secured to the frame through rubber fittings which absorb some of the shunting shocks. The driver's cab is arranged to that the locomotive can be controlled from either side, the gear-change lever being duplicated. The range of instruments provided includes oil-pressure gauges for both the engine and gearbox lubricating systems, air brake and starting-air pressure gauges and a speedometer; the arrangement of the controls and instrument within the cab is shown in Fig. 7, on this page.

An idea of the performance of the locomotive can be gained from the following figures which have been

supplied by the manufacturers. The maximum drawbar pulls in first, second and third gears are 7,550 lb. 3,975 lb. and 2,275 lb., respectively, the corresponding tractive efforts being 7,850 lb., 4,200 lb. and 2,500 lb., The maximum load which can be hauled depends, naturally, on the rolling resistances of the train, but assuming a resistance of 20 lb. per ton in first gear, and 15 lb. per ton in second and third gears, the locomotive, when in top gear, can haul 152 tons on the level, 40 tons up a gradient of 1 in 75, and 13 tons up a gradient of 1 in 30. The corresponding figures, when working in first gear, are 377 tons on the level, 142 tons up a gradient of 1 in 75, and 68 tons up a gradient of 1 in 30. These figures, however, apply to a locomotive working on a straight track, and due allowance must be made when it is proposed to use it on a track having sharp curves, bearing in mind the fact that the minimum curve the locomotive can negotiate, with usual widening of track, is of 80 ft. radius.

INSTITUTION OF NAVAL ARCHITECTS.

THE annual general meeting of the Institution of Naval Architects will be held at the Royal United Service Institution, Whitehall, London, S.W.1, on Wednesday, Thursday and Friday, March 17, 18 and 19. The annual dinner of the Institution will be held on the first day, at 7.15 for 7.30 p.m., in the Grand Hall, Connaught Rooms, Great Queen-street, London, W.C.2.

The meeting opens at 10.15 a.m., on Wednesday, March 17, when the annual report of Council will be presented and the election of the President and officers will be held. After this, premiums and prizes will be presented, and the President, Admiral of the Fleet Viscount Cunningham of Hyndhope, K.T., G.C.B., will deliver his presidential address. The last matter on the agenda, that morning, will be the presentation of a paper entitled "Speed at Sea and Dispatch in Port," by Mr. W. Macgillivray.

On the second day, Thursday, March 18, the meeting opens at 10.15 a.m., when two papers will be presented, namely, "Ship-Repairing and Shipyard Problems in the Invasion of Europe," by Mr. A. J. Merrington, C.B.E., R.C.N.C., and "The Royal Navy and Nuclear Power," by Mr. R. J. Daniel, R.C.N.C. In the afternoon, the meeting will commence at 2.30 p.m., when, again, two papers will be presented; the first, by Commander (E) A. D. Bonny, R.N., on "The Effect of Non-Contact Explosions on Warship Machinery Design," and the second, by Constructor-Commander J. F. Starks, R.C.N.C., on "German U-Boat Design and Production."

On the third day, Friday, March 19, morning and afternoon meetings will again be held at 10.15 a.m. and 2.30 p.m., and two papers will be presented at each session. Those taken at the morning session comprise "Temporary Hull Repairs to Tanker Markay" by Mr. A. Reid; and "Calculations Illustrating the Effect of Boundary Layer on Wave Resistance," by Professor T. H. Havelock, F.R.S. The two papers considered at the afternoon session are entitled "Small Model Experiments and Viscosity Effects," by Mr. R. T. Shields, and "An Examination of the Pressure Distribution over a Model Hull," by Mr. J. McCallum.

The offices of the Institution are at 10, Upper Belgrave-street, London, S.W.1.

PRODUCTION OF TITANIUM HYDRIDE.—Messrs. Murex, Limited, Rainham, Essex, inform us that one of the rarer metallurgical products, hitherto imported from the United States, is now being manufactured by them in this country. This material, titanium hydride, is produced with a titanium content of 98 per cent. and is utilised in powder metallurgy and in various special applications, such as the manufacture of microwave valves.

TRACK RELAYING IN POLHILL TUNNEL: ADDENDUM.—Owing to bad weather, the relaying of the track in Polhill Tunnel, on the Southern Region of British Railways, was postponed for a week. The tunnel, which is 2,611 yards in length, was closed on the night of Saturday, February 28, and not a week previously, as reported on page 211, *ante*. On visiting the tunnel this week, we were able to see the Insley excavator with skimmer attachment, removing dirty ballast to a depth of 9 in. below the level of the underside of the sleepers, on the centre section of the up line. It was stated that the programme of work is being adhered to, and that the engineers are, in fact, slightly ahead of schedule. When the tunnel is opened on Monday, March 22, it is anticipated that speed restrictions will be: 30 m.p.h., increased to 45 m.p.h. within seven days, on the up road; and 15 m.p.h., increased to 30 m.p.h. within seven days, and increased to 45-50 m.p.h. after a further seven days, on the down road.

BOOKS RECEIVED.

Ministry of Supply. Directorate of Royal Ordnance Factories. Explosives. Industrial Experimentation. Third edition. By K. A. BROWNLEE, H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3s. net.]

Report on the Progress and Condition of the United States National Museum for the Year Ended June 30, 1947. Smithsonian Institution, Washington, D.C., U.S.A.

Science News. No. 6. Penguin Books, West Drayton, Middlesex. [Price 1s. 6d. net.]

Proud Heritage. A History of Thomas Smith and Sons (Rodley), Limited. Thomas Smith and Sons (Rodley), Limited, Town-street, Rodley, Leeds.

Massachusetts Institute of Technology. Radiation Laboratory Series. Volume 25. *Theory of Servomechanisms.* Edited by PROFESSOR HUBERT M. JAMES, NATHANIEL B. NICHOLS and RALPH S. PHILLIPS. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 5 dols.] McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 30s.]

Textbook of the Materials of Engineering. By PROFESSOR HERBERT F. MOORE. Seventh edition. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 5 dols.] McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 30s.]

La Foudre. By PROFESSOR CHARLES MAURAIN. Librairie Armand Colin, 103, Boulevard Saint-Michel, Paris (Ve). [Price 120 francs.]

Vertical Boiler Defects and Repairs. By SYDNEY D. SCORER. John D. Troup Limited, 90, High Holborn, London, W.C.1. [Price 5s. 6d., post free.]

The Symbolic Method of Vector Analysis. The "j" Operator Simply Explained. By W. H. MILLER. Classifax Publications, 9, White Moss-avenue, Manchester 21. [Price 3s.]

Principles of Management. By M. A. CAMERON. George G. Harrap and Company, Limited, 182, High Holborn, London, W.C.1. [Price 2s. 6d. net.]

Rubber in Textile Factories. By COLIN MACBETH. The British Rubber Development Board, Market Buildings, Mark-lane, London, E.C.3. [Free.]

Nigeria. Annual Report of the Electricity Branch, Public Works Department, for the Year 1945-46. Government Printer, Lagos, Nigeria; and the Crown Agents for the Colonies, 4, Millbank, London, S.W.1. [Price 9d.]

South African Mining and Engineering Year Book, 1947-48. Edited by S. R. POTTER. South African Mining Journal Syndicate, Limited, 201-207, Jubilee House, Johannesburg; and Argus South African Newspapers, Limited, 85, Fleet-street, London, E.C.4. [Price 45s., post free.]

Wiring a Continent. The History of the Telegraph Industry in the United States, 1832 to 1866. By ROBERT LUTHER THOMPSON. Princeton University Press, Princeton, N.J., U.S.A. [Price 7.50 dols.] Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 42s. net.]

Society of Chemical Industry. Chemical Engineering Group. Proceedings. Volume 26. 1944. The Secretary, The Chemical Engineering Group, 56, Victoria-street, London, S.W.1. [Price 21s.]

Tables of Properties of Gases. With Dissociation Theory and Its Applications. By Dr. E. W. GEYER and E. A. BRUGES. Longmans, Green and Company, Limited, 6 and 7, Clifford-street, London, W.1. [Price 12s. 6d. net.]

Ministry of Fuel and Power, and British Intelligence Objectives Sub-Committee. Technical Report on the Ruhr Coalfield. By a Mission from the Mechanisation Advisory Committee of the Ministry of Fuel and Power. Volume III. Appendix No. 26. *The Efficient Utilisation of Shaft Space.* By DR. ING. HERMANN SCHÄFER. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2s. 6d. net.]

Gradients of the British Main-Line Railways. The Railway Publishing Company, Limited, 33, Tothill-street, Westminster, London, S.W.1. [Price 10s.]

Handbook to the Factories Act and Truck Acts. By JOSEPH OWNER. Third edition. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 7s. 6d. net.]

Shadow and Diffusion in Illuminating Engineering. By DR. KONRAD NORDEN. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 25s. net.]

Department of Scientific and Industrial Research. Food Investigation. Leaflet No. 9. *Entrepôt Cool Storage of Fruit and Vegetables.* By DR. J. C. FIDLER. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2d. net.]

Modern Operational Calculus. With Applications in Technical Mathematics. By DR. N. W. MCLACHLAN. Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 21s. net.]

The Story of the West Highland. Second and enlarged edition. By GEORGE DOW. Eastern and North-Eastern Regions, British Railways, 11, Blandford-square, London, N.W.1. [Price 3s. 6d.]

PERSONAL.

DR. MORRIS REED, M.Sc., M.I.E.E., has been appointed chief radio engineer of the Mitcham Works of Philips Electrical, Limited, Century House, Shaftesbury-avenue, London, W.C.2.

SIR GRAHAM CUNNINGHAM, who was chief executive and Controller-General of Munitions Production, Ministry of Supply, during the late war, has been made chairman of a new committee appointed by the Minister of Supply to inquire into scrap and pig-iron supplies.

MR. H. H. SWIFT, B.E. (Adelaide), M.I.E.E., has been appointed acting electrical engineer, British Railways, Eastern and North Eastern Regions.

MR. E. B. HILL, of Charles Hill and Company, Limited, has been elected chairman of the Zinc Alloy Die Casters Association, Lincoln House, Turl-street, Oxford, for 1948, in succession to MR. A. E. MILLS, of the British Die Casting and Engineering Company, Limited. Mr. Mills and MR. J. W. CARTLIDGE, of Dyson and Company, Enfield (1919), Limited, are to act as deputy chairmen.

MR. BASIL W. DONCASTER has been elected President of the Sheffield Society of Engineers and Metallurgists.

MR. NORMAN E. ALLENDER, B.Sc. (Eng.) (Lond.), A.M.I.Mech.E., is now Principal of Old Swan Technical Institute, Broadgreen-road, Liverpool.

MR. H. C. HARLAND, F.R.I.C.S., a director of Messrs. John Laing and Son, Limited, Mill Hill, London, N.W.7, has retired.

MR. A. G. REDWOOD is now in charge of the department of planning engineers, Standard Telephones and Cables, Limited, New Southgate, London, N.11.

MR. C. L. O'HIGGINS, B.Sc. (Eng.) (Lond.), has been appointed senior development engineer in the works of Ascot Gas Water Heaters, Limited, Neasden, London, N.W.10.

MR. W. S. BENNETT, A.M.I.Mech.E., has been made deputy chief draughtsman of the National Smelting Company, Limited, Avonmouth.

MR. C. J. HORNSBY, who has been with the Electricity Commissioners since 1920 and has been assistant secretary to the Commission since 1945, has now been made assistant secretary to the British Electricity Authority.

MR. T. A. COOK, A.M.I.Mech.E., has joined the staff of the Vulcan Boiler and General Insurance Company, Limited, London, as engineer surveyor.

MR. A. L. CREWE has been made general assistant to the Chief Regional Officer, Eastern Region, British Railways.

MR. J. TURNER, previously goods agent, London Midland and Scottish Railway, Sheffield (Wicker), has been promoted to the position of docks superintendent, Garston Docks, British Railways (London Midland Region).

MR. D. B. JOHNSON, A.M.I.Mech.E., is now assistant technical officer, Engineering Department, Imperial Chemical Industries, Limited, Plastics Division, Welwyn Garden City, Hertfordshire.

MR. S. H. BROOKS is relinquishing his position as fuel engineer to Messrs. Stewarts and Lloyds Limited, Corby, and is joining the staff of the Research and Technical Department, United Steel Companies, Limited. He will act as assistant to MR. F. A. GRAY, who is in charge of the fuel section of the Department.

MR. A. F. ECA DA SILVA, Rua Candido Mendes, 105, Apto. 501, Rio de Janeiro, has been appointed resident sales engineer, in Brazil, of Specialloid, Limited, North Finchley, London, N.12, as from February 15.

MR. A. B. STOBART has been appointed assistant commercial manager and a director of Messrs. John Summers and Sons, Limited, Hawarden Bridge Steelworks, Shotton, Chester.

SWISS INDUSTRIES FAIR.—The thirty-second Swiss Industries Fair will be held at Basle from April 10 to 20. Trade inquiries should be addressed to the Swiss Legation, 18, Montague-place, Bryanston-square, London, W.1, while Press inquiries should be addressed to Mr. W. H. T. Tayleur, 66, Avenue-chambers, Vernon-place, London, W.C.1.

ROAD TRANSPORT EXECUTIVE.—The long-distance road-haulage undertakings, which are to be acquired by the British Transport Commission in accordance with the Transport Act, 1947, will be re-organised in about 10 or 12 divisions, and each division will be sub-divided into districts. Departmental officers at divisions will comply with such instructions as may be issued by the Road Transport Executive to secure uniform practice and technical standardisation. In announcing these plans, Sir Cyril Hurcomb, chairman of the British Transport Commission, said it would require several months for the Commission and the Executive to negotiate for the acquisition of the undertakings, and they would certainly not issue notices of acquisition before October 1, 1948. They were taking steps to examine the means by which co-ordination of road and rail, goods and passenger transport, could best be achieved.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel.—On one day last week five ships were unloading simultaneously at Grangemouth a total of some 12,000 tons of scrap from Germany, while a further cargo of between 4,000 and 5,000 tons arrived a day or two afterwards, with prospects of still more to follow. Such a tonnage, which is sufficient to keep one of the large steelworks supplied for about two weeks, materialy brightened the prospect for resumed production from the three Lanarkshire furnaces temporarily closed down last month. Production from the reduced number of furnaces was maintained at a satisfactory level. Billets have been fairly plentiful in most sizes over 3 in. square, but below that range the acute scarcity has continued. Fair tonnages of re-rollable scrap have been forthcoming from different sources, and where suitable furnaces are available, re-rollers have been utilising this scrap to eke out their billet stocks. Pig-ron outputs are being maintained at recent satisfactory levels, but some anxiety was felt regarding the curtailment of metallurgical-coke deliveries following the dispute at South Yorkshire and other coke-ovens in the south. Further progress has been made with the new blast-furnace at Tollcross Works, and only slight final adjustments are now required before the unit settles down to routine production of basic iron of the desired analysis. Outputs for the time being will be below the maximum designed capacity of the furnace owing to the limited allocation of coke.

Scottish Coal.—A sequel to events at Priory Colliery during the past few years in general, and last month in particular, has been the posting of a notice at the pithead to the effect that any future stoppage, either partial or complete, will mean the immediate closing of the colliery so far as production is concerned There is a possibility that if this drastic step should become necessary, the colliery will be re-organised as a training centre for recruits. Strikes reduced the production from the Central Areas in the last week of February from 193,400 tons to 184,600 tons, but the decline was largely offset by an increase of 6,000 tons in Ayrshire, where the total of 77,400 tons was the highest for the year. The following week a strike was staged at Shewalton Colliery, Ayrshire West, when oncost workers came out for a few days over a question of bonus payments on outputs. The net improvement in Divisional production in the week ended February 28 was 2,800 tons, raising the weekly figure to 478,700 tons. At the same time, the current deficit for the year was increased to 185,000 tons, total outputs for the weight weeks aggregating 3,815,000 tons, in comparison with a target figure of 4,000,000 tons. Production has been sufficient to meet the local consumption needs, largely on account of the favourable weather in recent weeks. Electric power stations, gasworks, coke-ovens, railways, steelworks, and other priority users have all received adequate tonnages, while a satisfactory supply of industrial and steam fuels has been provided for general industry. Coals for domestic use have been ample, and instances have occurred in Ayrshire of merchants refusing supplies owing to difficulty of disposal to householders. Export trade has been quieter. Regular shipments have been moving to Sweden and Eire, while a steady flow of inquiries continues.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Blast-furnaces have been seriously affected by the more pronounced scarcity of coke caused by the recent strike of coke-oven men. The curtailment of coke-oven supplies by about 50 per cent. made it necessary to restrict supplies of gas for industry to a serious extent. At first many departments were without gas, but later the supply was 50 per cent. and then 75 per cent. of the normal. The settlement of the dispute made it possible to restore gas supplies by Saturday. There is a continued shortage of high-carbon steel, supplies being insufficient to meet the demands of the rolling mills. Many industries are unable to work full time because the supplies of high-carbon steel sheet and bar are inadequate. Makers of agricultural machinery are unable to complete orders for parts urgently required by agricultural-machinery makers for machinery required for this year's harvest. Negotiations are taking place between agricultural-machine part manufacturers, the Minister of Agriculture and the British Iron and Steel Federation in an effort to improve supplies.

South Yorkshire Coal Trade.—Foggy periods have restricted the transport of coal and some users have had to draw upon their reserves. Fair supplies of locomotive hards have been reaching railway locomotive depots. Electricity-generating plants are fairly well supplied but gas coal is short because of its greater use during the coke-oven men's strike. Washery fines for firing Lancashire boilers are in good demand, and there is a constant call for fines for making domestic fuel. Open-cast sites have been yielding about the usual quantities of fuel and these have been directed to several sections of the market.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The aggregate tonnage output of iron and steel in the Tees-side area remains at a very high level, but producers are still unable to cope fully with current requirements. Customers, both at home and abroad, are calling for larger deliveries. The yield of local ironstone is still on a disappointing scale, necessitating the continued extensive use of foreign ore. No material improvement in the distributable tonnage of iron and steel scrap can be reported. Supplies of all classes of pig iron are readily taken up and the demand for larger parcels of various descriptions of steel remains intense.

Foundry and Basic Iron.—Foundry outputs are still adversely affected by the shortage of pig iron and heavy cast-iron scrap. This is unfortunate as orders for several commodities are accumulating. Tees-side blast-furnaces are making only small occasional parcels of iron suitable for foundry use and most of the quality required for the production of castings has to be brought by rail from the Midlands; deliveries are not as regular as could be desired and are much below requirements. The make of basic iron is now on a reasonably satisfactory scale though it is passing into use promptly at the producers' own consuming plants. Larger deliveries of good heavy steel scrap would be very welcome.

Hematite, Low-Phosphorus and Refined Iron.—Manufacturers of East-Coast hematite cannot yet supply their regular customers with iron for stock, but are able to maintain deliveries at a rate that covers essential requirements. Outputs of low- and medium-phosphorus grades of iron are passing steadily into use at local works, and makers of refined qualities are able to dispose of their products as soon as they can be delivered.

Manufactured Iron and Steel.—Makers of semi-finished and finished iron are busily occupied and have good bookings, while steel producers are overwhelmed with orders. The demand for steel semies is still greatly in excess of supplies. Imports are small but makers have been able to increase slightly the deliveries to the re-rolling mills where additional export orders have been placed for shipment this month. Billets, blooms, slabs and sheet bars continue in very strong demand. There is no reduction in the intense demand for all finished commodities. Heavy-steel makers have large commitments and are anxious to increase March deliveries, realising that unexecuted orders at the end of the month may have to be cancelled or re-authorised for distribution over the second quarter of the year. The output is greater than ever, but the demand is still far in excess of the supply. Buyers with substantial running contracts for sheets, joists, shipbuilding requisites, railway material and colliery equipment are calling for maximum deliveries.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Welsh Coal Trade.—A strike of 800 South Wales coke-oven men who ceased work in sympathy with similar employees in Yorkshire was of short duration. Hardly had the Welsh men ceased work than news of the Yorkshiremen's return was received and the local men decided to do likewise. News that the Lord Chancellor had announced in Rome that Britain had agreed to send at least 400,000 tons of coal to Italy this year has been received with interest locally. Italy has always been an important market for Welsh coals and trade was resumed recently after the war-time suspension. The governing factor at present has been the ability of South Wales to supply. Recent agreements which provide for the supply of coal to Argentina, Eire, France and Portugal have accounted almost entirely for the coal which could be spared for delivery abroad this month and before there can be any material expansion there will have to be a considerable increase in outputs. Activities on the Welsh steam-coal market throughout the week have been severely checked by the shortage of supplies. The requirements of the home industry were very heavy and, as a rule, orders already in hand from this direction were sufficient to provide a ready outlet for the bulk of potential outputs over some time to come. The recent activity on export account was sufficient to account for the month's allocations, and as a result there has been a lull, although the number of orders available from foreign buyers has shown no diminution. Cokes and patent fuel were in brisk request, but supplies were difficult to arrange for delivery over the next month.

Swansea Steel-Sheet Industry.—The market report issued by the Incorporated Swansea Exchange states that, last week, business in tin-plate was firm, although home consumers were not buying any appreciable quantities. Makers have good order books and are able to maintain production. In the export market business was less active last week, and the sales were below those of the previous week. Steel sheets continue to be in demand as is also the case with iron and steel scrap.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

JUNIOR INSTITUTION OF ENGINEERS.—*North-Western Section:* Monday, March 15, 7 p.m., 16, St. Mary's Parsonage, Manchester. Various short papers. *Institution:* Friday, March 19, 6.30 p.m., 39, Victoria-street, S.W.1. "Machinator: Quo Vadis?" by Mr. L. S. Atkinson.

INSTITUTION OF ELECTRICAL ENGINEERS.—*London Students' Section:* Monday, March 15, 7 p.m., Victoria-embankment, W.C.2. "Domestic Electrical Installation Practice," by Mr. G. J. Hughes. *Institution:* Thursday, March 18, 5.30 p.m., Victoria-embankment, W.C.2. "Load Dispatching with Reference to the British Grid System," by Mr. A. R. Cooper. *Measurements and Transmission Sections:* Friday, March 19, 5.30 p.m., Victoria-embankment, W.C.2. "Influence of Inverse Time Relay Characteristics on Discriminative Time," by Messrs. E. W. Connon and E. Smith.

INSTITUTE OF METALS.—Institution of Civil Engineers, Great George-street, S.W.1. Tuesday, March 16, 2.30 p.m.; Wednesday, March 17, 10 a.m., 2.30 p.m.; Thursday, March 18, 10 a.m. Annual General Meeting. For programme, see page 202, *ante*.

ROYAL SOCIETY OF ARTS.—Tuesday, March 16, 2.30 p.m., John Adam-street, W.C.2. "Co-ordination of Research in the Pacific," by Dr. E. Marsden.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, March 16, 5.30 p.m., Great George-street, S.W.1. "Reconstruction of Bamford Filters," by Mr. R. W. S. Thompson. *Yorkshire Association:* Friday, March 19, 7 p.m., Great Northern Station Hotel, Leeds. "Pumping Machinery," by Mr. H. R. Lupton.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—Tuesday, March 16, 6.15 p.m., 2, Savoy-hill, W.C.2. "Electricity for Space-Heating of Buildings," by Mr. H. H. Bruce.

INSTITUTION OF THE RUBBER INDUSTRY.—*London Section:* Tuesday, March 16, 7 p.m., Caxton Hall, Victoria-street, S.W.1. "New Condensation Rubbers," by Dr. D. A. Harper.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—Wednesday, March 17, 6 p.m., Institution of Mechanical Engineers, Storey's-gate, S.W.1. "Air Heaters," by Mr. A. Connor Wilson.

DIESEL ENGINE USERS ASSOCIATION.—Thursday, March 18, 2.30 p.m., Caxton Hall, Victoria-street, S.W.1. "Diesel-Electric Traction," by Mr. T. Hornbuckle.

INSTITUTION OF MINING AND METALLURGY.—Thursday, March 18, 5 p.m., Geological Society, Burlington House, Piccadilly, W.1. "Converter Practice at Rio Tinto," by Mr. H. R. Potts.

ROYAL AERONAUTICAL SOCIETY.—Thursday, March 18, 6 p.m., Institution of Civil Engineers, Great George-street, S.W.1. "Flight Testing at High Subsonic Speeds," by M. H. Davies.

INSTITUTION OF MECHANICAL ENGINEERS.—*Midland Branch:* Thursday, March 18, 6 p.m., James Watt Institute, Birmingham. "Investigation of Scuffing and Wear by New Test Methods," by Messrs. S. G. Daniel, H. F. Kenyon and T. B. Lane. *North-Western Branch:* Thursday, March 18, 6.45 p.m., Engineers' Club, Manchester. "Physical Properties Relied on in the Frozen-Stress Technique," by Mr. W. A. P. Fisher. "Modern Applications of Photo-Elasticity," by Mr. R. B. Heywood. *Institution:* Friday, March 19, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Annual General Meeting. AUTOMOBILE DIVISION. *Scottish Centre:* Monday, March 15, 7.30 p.m., 39, Elmbank-crescent, Glasgow. "Large-Scale Vehicle Overhaul and Repair," by Mr. E. C. Ottaway. And at the *Western Centre:* Thursday, March 18, 6.45 p.m., Grand Hotel, Bristol. *Luton Centre:* Tuesday, March 16, 6.30 p.m., George Hotel, Luton. "Test Methods and Some Instruments," by Mr. E. B. Stead. *Derby Centre:* Thursday, March 18, 7 p.m., School of Arts, Green-lane, Derby. "Road Motor Vehicles," by Mr. Maurice Platt.

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN.—*Scientific and Technical Group:* Thursday, March 18, 7 p.m., 16, Princes-gate, S.W.7. Symposium on "Photography in Nuclear Research."

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, March 19, 6.15 p.m., Mining Institute, Newcastle-upon-Tyne. "Experimental Work on Merchant Ship Models During the War," by Messrs. Arnold Emerson and N. A. Witney.

MANCHESTER ASSOCIATION OF ENGINEERS.—Friday, March 19, 6.45 p.m., Engineers' Club, Manchester. "Wire and Wire Products," by Mr. R. S. Brown.

ROYAL INSTITUTION.—Friday, March 19, 9 p.m., 21, Albemarle-street, W.1. "Metal Physics," by Professor Sir Lawrence Bragg, F.R.S.

RAISING GROUND LEVEL BY SAND PUMPING AT SHOTTON, NEAR CHESTER.

WESTMINSTER DREDGING COMPANY, LIMITED, LONDON.

(*For Description, see Page* 241.)

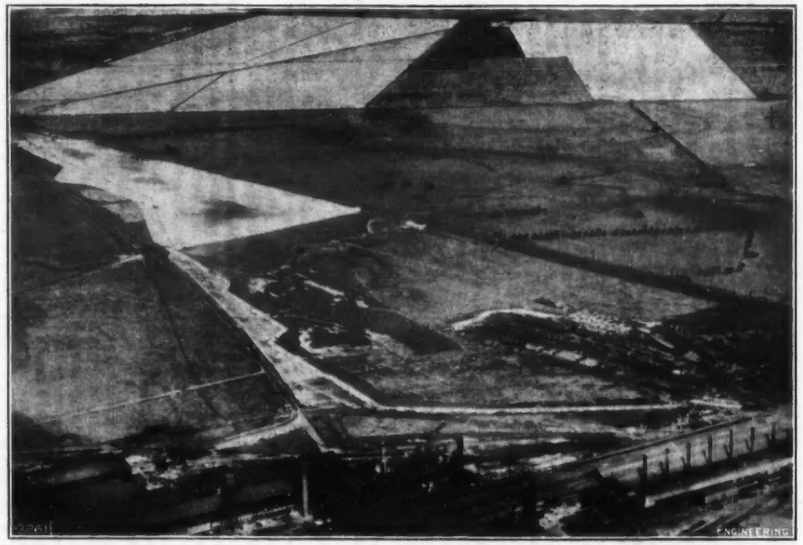


FIG. 5. SITE OF FILL, LOOKING NORTH-EAST.

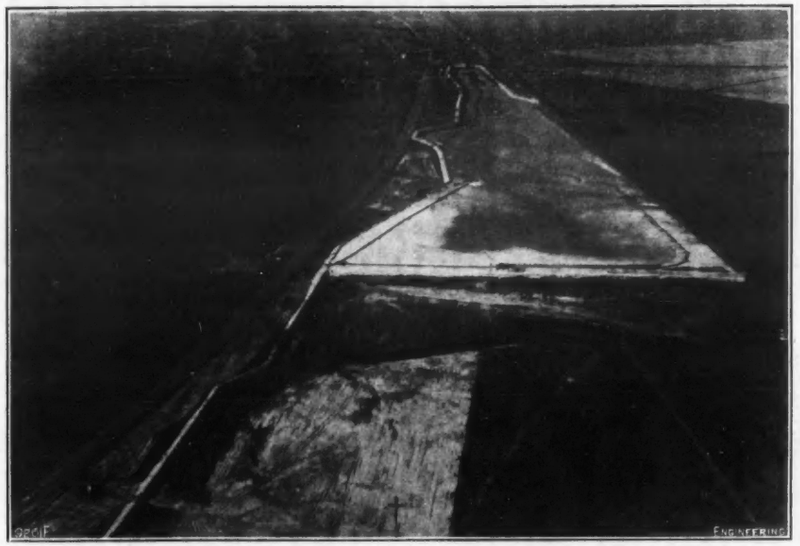


FIG. 6. SITE OF FILL, LOOKING NORTH.

FIG. 7. FLOATING PIPELINE.

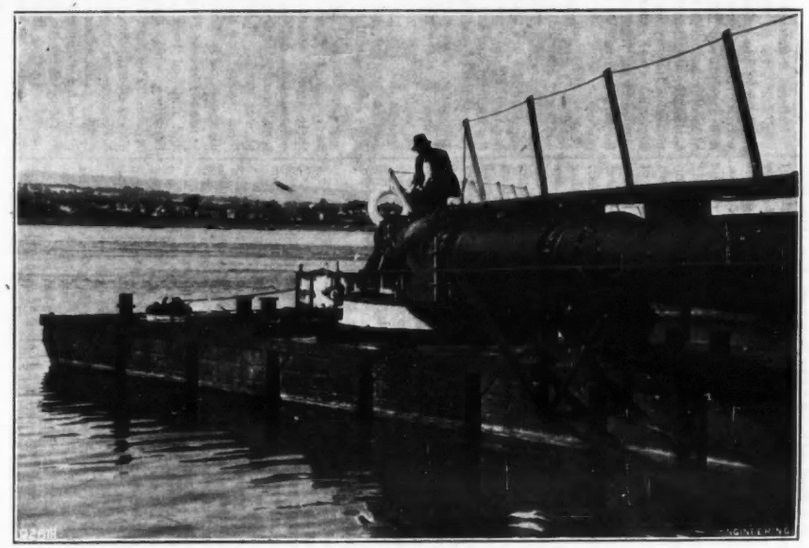


FIG. 8. PIPELINE PONTOON AND TURNTABLE.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

Telegraphic Address:

"ENGINEERING," LESQUARE, LONDON.

Telephone Numbers:

TEMPLE BAR 3663 and 3664.

All editorial correspondence should be addressed to the Editor and all other correspondence to the Manager

Accounts are payable to "ENGINEERING," Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

SUBSCRIPTIONS.

"ENGINEERING" may be ordered from any newsagent in town or country and from railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months (or for six or three months, *pro rata*), payable in advance:—

For the United Kingdom and all places abroad, with the exception of Canada	£4 10 0
For Canada	£4 5 0

Subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, mentioning the agent's name and address.

ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for inserts, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 8*s.* for the first four lines or under, and 2*s.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 24*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

CONTENTS.

	PAGE
Raising Ground Level by Sand Pumping (*Illus.*)	241
Literature.—Influence Lines: Their Practical Use in Bridge Calculation. Chimie Organique. Vol. I. Chimie Organique générale; Vol. II. Fonctions simples. Tables of the Bessel Functions of the First Kind of Orders Four, Five and Six. Tables of the Bessel Functions of the First Kind of Orders Seven, Eight and Nine	243
An Early Kitson Locomotive (*Illus.*)	244
Research in Australia	245
Electricity Supply in Eccles	246
Water-Tube Boilers at Clyde's Mill Power Station	247
Annuals and Reference Books	247
100-B.H.P. Mining Locomotive (*Illus.*)	248
Institution of Naval Architects	250
Books Received	250
Personal	250
Notes from the North	251
Notes from South Yorkshire	251
Notes from Cleveland and the Northern Counties	251
Notes from the South-West	251
Notices of Meetings	251
The Navy Estimates	253
Mines Research	254
Notes	255
Letters to the Editor.—Tests of 4-4-4-4 Passenger Locomotive, Pennsylvania Railroad. Peter Willans. Council Elections in Professional Institutions	255
Obituary.—Major H. P. M. Beames, C.B.E.	257
The Engineering Outlook—XI	257
Labour Notes	260
The Gas Turbine as Applied to Marine Propulsion (*Illus.*)	261
Catalogues	264

ENGINEERING

FRIDAY, MARCH 12, 1948.

VOL. 165. No. 4285.

THE NAVY ESTIMATES.

LESS than two months ago, when we reviewed (on page 61, *ante*) Lord Chatfield's recent book, *It Might Happen Again*, we quoted from it the five principles which he postulated as the only sure basis of a national defence policy. After so short an interval, it is not necessary to recapitulate them *in extenso*, but a brief résumé may be timely as a criterion by which to judge the Navy Estimates, presented to Parliament on Monday of this week. As a prime essential, said Lord Chatfield, peace strength must be in accord with the power to recover to war strength. Because that recovery to war strength can only be a slow process, defence policy should not change with changes of Government; the safety of the country should be a first charge on finance, and the annual estimates should be presented to Parliament in a combined form. Finally, "foreign policy must be in accord with actual national strength." The fourth of these requirements may be held to have been satisfied, for practical purposes, by the publication of the *Statement Relating to Defence*, 1948 (Cmd. 7327), in which the man-power and cost of the three Services were surveyed jointly—the Navy, incidentally, coming third under both headings; but it cannot be said that any one of the other four considerations was satisfied by the Estimates that were presented by Mr. John Dugdale, the Parliamentary and Financial Secretary to the Admiralty, to the House of Commons, and discussed there and in the House of Lords, on March 8. Both Mr. Dugdale and, in the Upper House, Lord Hall, the First Lord of the Admiralty, made great play with the names and numbers of the various warships which, they claimed, would be in service again towards the end of the present year; but, in general, their arguments seemed more ingenious than convincing, especially in the light of recent events in the South Atlantic, in British Honduras, and elsewhere.

The First Lord's *Statement Explanatory of the Navy Estimates*, 1948-49 (Cmd. 7337) shows that 153,000,000*l.* is to be provided for the Navy in the period mentioned, this being a reduction of 43,700,000*l.* on the figure for the previous year; and that the combined establishment for the Royal Navy, Royal Marines and ancillary Services will amount to 167,300. As a summary of the more detailed text of the full Navy Estimates, however, the First Lord's statement cannot be regarded as wholly satisfactory, being too much a survey of the events of the immediate past and not sufficiently a pointer to the more significant items in the full text; for instance, it does not specify the amount to be expended on research during the coming year, nor does it give appropriate prominence to the fact that no new construction is to be initiated, though some progress (at a reduced rate) will be made with the ships which are still in the builder's hands, actually or technically. The most immediately important part of the *Statement*—the section headed "Strength and Build-up of the Fleet"—occupies less than a page and consists almost wholly of a table showing the vessels of the Fleet by classes. It is so liberally provided with footnotes, however, and with the relative reference marks in the table itself, that the task of disentangling the details to ascertain what is the real strength of the Navy at the present time is by no means easy. What is painfully obvious is that its strength is not nearly enough; nor does it appear to be adequate even if the whole of the ships listed were ready to put to sea.

According to this table, the vessels comprising the Royal Navy now consist of five battleships, six fleet carriers, seven light fleet carriers, one escort carrier, 31 cruisers, 117 destroyers, 179 frigates, two monitors, 65 submarines, and 68 minelayers. Vessels under construction comprise two large and ten light aircraft carriers, three cruisers, ten destroyers and two frigates; though, it is added, work on some of these ships is temporarily suspended. The figures quoted do not include ships officially listed as being for disposal, except in the case of one light fleet carrier (H.M.S. Venerable), which is to be transferred to the Royal Netherlands Navy, and two cruisers, to be handed over to India and China, respectively. On the face of things, therefore, and bearing in mind the enhanced fighting value of many of the present-day ships by comparison with corresponding vessels of even ten years ago, it appears on paper that a fairly considerable fleet is more or less in being; but it is at this stage that the purport of the numerous footnotes requires to be examined. Of the five battleships, two (the Duke of York and the Vanguard) will not be "operational" before August or September, one (the King George V) is in reserve, and the remaining two (the Anson and the Howe) are entered in the column headed "Training and Experimental, etc. (Special Complements)"; what that description may mean, Their Lordships doubtless know if Parliament and the public do not, but the possibility that it means that these two ships are efficient fighting units may be dismissed.

Of the six large fleet carriers, three are in reserve, one is "Training and Experimental," and two others, in the same category, are "temporarily immobilised until Autumn, 1948" in one case and "operational by end of 1948 or early 1949" in the other. Two of the light fleet carriers appear to be immediately available, two others should be so by June or July; but the fifth is marked "Date uncertain" (though included under the "Operational" heading), the sixth (H.M.S. Venerable) is earmarked for transfer to the Royal Netherlands Navy, and the seventh (H.M.S. Warrior), at present on loan to Canada, is to be taken in hand for a refit when she is returned. Of the 16 cruisers in the "Operational" list, one will not become so until next month, four more not until the autumn, and another not until the end of the year; and the Superb is to be "immobilised" in August. Two cruisers are being used for training purposes, and the rest are in reserve. Sixteen of the 34 "operational" destroyers are not available at present; 18 are on training, etc., duties; and 65 are laid up. Of the 179 frigates, 136 are laid up; and of the 65 submarines, 31 are in the reserve.

In the debates in both Houses of Parliament, a good deal was said about the scrapping of the old battleships of the Queen Elizabeth and Royal Sovereign classes, together with the Nelson and

Rodney; but much of it seemed to be inspired by sentiment more than practical insight, and Major W. Vernon, the Member for Dulwich, had some justification for his professed astonishment that, after so much had been written in favour of abolishing battleships, so many champions of the type should have arisen to defend them. A few of them might have been retained for a while longer; but battleships are somewhat costly media for mere flag-showing, and, notwithstanding the undoubtedly impressive appearance of a battery of 15-in. guns, it is probable that these old ships will perform a more useful service as scrap metal than they could do if retained on the nominal strength of the Navy. Most of them have been through two wars, in which they did not entirely escape damage, and it has been generally held that one year of war service corresponds to at least two years of peace-time life as an ageing influence; by which criterion, they are getting on for 40 years old. Many of the critics of the Admiralty policy in this respect were probably unaware of the corrosive effect of fuel oil on the structure of a ship that contains it, and, without necessarily subscribing to the estimate of the Minister for Defence (Mr. A. V. Alexander) that the Nelson and Rodney could not be made serviceable for less than 11,000,000*l.*, we suspect that a serious proposal to spend any such sum upon them would have induced even stronger criticism than the protests against scrapping them.

While supporting the Government proposals to that extent, however, we feel some surprise that more was not made of the weakened state of the Navy's cruiser force; more particularly in the House of Lords, where the weight of professional experience brought to bear in the debate was more prominent than in the Commons. Before the war, it was stoutly maintained and never seriously challenged that the proper protection of the sea routes of the Empire required a force of 70 cruisers—twice the total now under the British flag, even if the Dominion navies are included. To some extent, no doubt, aircraft carriers might take over some of the work of commerce protection, though the losses of carriers so engaged, during the recent war, suggest that they are not particularly suited to such work. The Government spokesmen argued that the modern destroyer is the virtual equivalent of a light cruiser, which is true enough in some respects; but the destroyer is not so well fitted as a properly designed cruiser for the work of long-distance and long-term cruising, which is the cruiser's real (but sometimes forgotten) function.

The Estimates show that there are under construction, nominally or actually, two large aircraft carriers, ten light fleet carriers, three cruisers, ten destroyers and two frigates. Recent events suggests that, whether or not any more ships are laid down—and no new construction is contemplated during the year 1948-49—the completion of these vessels should not be unduly delayed. It may be, as some would argue, that the lessons of Bikini have rendered obsolete all the existing types of warship unless and until they can be radically modified to give better protection to the crews against radio-activity. That may be true of naval warfare in the narrow seas, but it cannot apply to the whole network of the Empire's sea lanes. Valuable naval bases overseas may be lost to the Fleet in a future war as a result of recent political changes, but the mileage of sea routes to be guarded has not been reduced; more probably, it would be increased. Over the greater part of that mileage, vessels of the present types would suffice for commerce protection if numerous enough; and only numbers of independent commands can produce numbers of experienced commanders. Lord Tovey—an outstanding commander of destroyers in the 1914-18 war—urged strongly, for this reason, that no small ships should be scrapped while they remained serviceable. "We have never had too many," he declared, "and we never shall have too many; and it is a false policy to get rid of any of them before it is absolutely necessary." Equally, however, it is desirable to retain sufficient ships of medium size, such as cruisers, which can serve as flagships of small fleets or flotillas (like the present "operational" Home Fleet), and cruise with relative ease at long distances from their bases.

MINES RESEARCH.

FOR the first twenty-five years of their existence, the Safety in Mines Research Board were financed mainly by grants from the Miners' Welfare Commission, who were financed by a levy on all coal mined. It is for this reason, no doubt, that the title of the organisation appears to restrict their activities to questions of safety. Such questions have undoubtedly dominated the activities of the Board, but their investigations and experimental work have necessarily touched on many matters bearing on the technical efficiency of various appliances and methods. The latest report* of the Board, for instance, contains a section dealing with tests carried out with various forms of metal roof props, some of telescopic type, or with various release arrangements, and some made of light alloy. The efficiency of roof props is certainly an aspect of safety, and properly comes within the Board's ambit, but it is also a matter affecting the efficiency of commercial exploitation. When the coal industry was nationalised at the beginning of last year, the Board ceased to be dependent on the Miners' Welfare Commission and are now financed by direct grants from the Exchequer, in the same way as the Building Research Board and similar bodies. As the nation as a whole is now directly concerned with the efficiency of coal winning, presumably this now-Government body will concern themselves with the efficiency of production methods and appliances; a reference in the latest report to Diesel, trolley and battery locomotives suggests that the Board may initiate a study of the proper sphere for the various types. An increase in the range of their activities, however, is hardly likely to result in the Board becoming the "Mines Research Board." The reaction of the uninstructed to the dropping of the word "safety" might have undesirable political repercussions.

During the first five years of their existence, the Board built research stations at Buxton and Sheffield, the former for large-scale work with artificial mine galleries and the latter for laboratory investigations. At the same time, a survey of the methods employed in supporting the roofs and sides of mine workings was carried out in various coalfields; haulage practice was also studied. Experimental work was at first directed mainly to the danger of explosions which "although not by any means the most prolific cause of accidents in mines, seemed to be most susceptible to further amelioration as a result of scientific attack." The work on the suppression, or elimination, of coal-dust explosions which has been carried on from the first, and is still proceeding, has unquestionably resulted in a reduction in the frequency and extent of these occurrences. The conditions of the general problem, however, are so complicated and vary so greatly in different instances that, even now, it is not possible to formulate specific rules about procedure or to recommend any particular type of stone dust for general use. In very many cases in practice it is clear that a layer of coal dust will form over a previously-deposited layer of stone dust, and to suppress propagation it is necessary that a disturbance should raise the underlying stone dust in a cloud along with the coal dust. Many years have been spent in studying the properties of different types of stone dust, but "the difference in efficiency so far observed between stone dusts of differing physical natures are disappointingly small." The problem, however, has not been given up.

The way to avoid the settling of a layer of coal dust over the stone dust is to apply the latter frequently, institute regular inspection, and avoid as far as possible the making and dissemination of coal dust. Such activities are widely practised, but can never be guaranteed to be performed perfectly in every part of every mine. In the limit, they represent a council of perfection. A method of preventing the raising of mine dust, which is being applied in South Wales, and is mentioned in the report, is to consolidate the floor by treatment with calcium chloride. Something may also be done by watering, but the usual stone dusts will not rise in a cloud when damp. To meet these conditions, and for use in wet roadways generally, waterproofed limestone dusts have been developed by a number of manufacturers. It is stated that they should not be employed in dry conditions as in such circumstances they are not so effective as untreated dusts.

The section of the report dealing with electrical researches contains further information bearing on the question of the performance of flameproof apparatus. The report for 1945 stated that experiment had shown that the long-accepted explanation that the quenching of a flame by a narrow gap between the flanges of a casing was due to the cooling effect was not correct, but no alternative explanation was offered. Further work has now led to the suggestion that the quenching effect depends on the speed of efflux of the flame and that the breadth of the flange has little effect on the safe gap; the volume of the enclosure may, however, play an important part as it governs the rate of pressure rise and hence the speed of efflux. Comparative tests are being carried out with casings of different sizes. Another electrical investigation was concerned with the use of fluorescent lamps for coal-face lighting. A series of tests was carried out to ascertain whether a lamp of this type, if broken when running normally, would ignite a methane-air mixture. The British Thomson-Houston Company supplied 100, 18-watt, 110-volt, lamps for these tests. They were broken when alight in a 9 per cent. methane-air mixture and in no case was the mixture ignited. This was an encouraging result, but it was considered desirable to devise experiments to determine if there was a factor of safety. The cathodes of these lamps reach a temperature of 1,200 deg. C. before discharge through the gas takes place, and it is considered that if they should be exposed to the gas mixture when at that temperature there would undoubtedly be an ignition. As it was not found possible to reduce the initial filament temperature to a safe value, it is proposed that, for mine use, provision should be made within the lamp housings to prevent the application of voltage to a broken lamp. Another electrical research concerned the possible ignition of coal dust lying on a hot surface, such as the control resistance box of an underground electric motor. A temperature of 250 deg. C. has been suggested as the maximum permissible, but in experiments with an electrically-heated plate, covered with $\frac{1}{8}$ in., $\frac{1}{4}$ in. and $\frac{1}{2}$ in. layers of coal dust, the dust began to glow at temperatures of 250 deg., 225 deg., and 180 deg., in periods varying from 105 to 60 minutes. It was accordingly decided that 250 deg. was too high a temperature to be safe. In any case, electrical apparatus should be kept reasonably clear of coal dust.

The tests on metallic mine props referred to above, covered a number made from light alloy. These included examples made from aluminium and magnesium. In the case of two of the latter, overloaded to failure, brilliant flashes occurred, apparently due to abraded particles of the metal. In view of this, it was ruled that magnesium could not be considered for props or other underground supports. Tests were carried out on five extruded props made of aluminium alloy of the Duralumin type, different props having received different heat treatment. Two, which had been annealed, carried a maximum load of 39 tons with a deflection between 1 and 2 in. The strength increased considerably in repeat tests after re-straightening and approached that of a 4 in. by 4 in. mild-steel prop. After being bent and re-straightened, some six to eight times, they gradually failed through distortion of the section at mid-length. The strongest prop was one of heat-treated alloy which sustained a load of 93·5 tons, but its durability was less than that of the annealed props. These aluminium props were 4 in. square, with rounded corners and a central cavity $3\frac{1}{4}$ in. in diameter. Favourable results have been obtained in trials in two collieries with a form of hydraulic prop. In one case, the height at the face varied from 5 ft. to 6 ft. The props gave continuous service for four months without attention and were easy and safe to use, but extended experience would be necessary to determine the time saved by their use. They are presumably relatively expensive, but the report states that they are suitable for mass production.

* *Twenty-fifth Annual Report of the Safety in Mines Research Board*, 1946. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* 3*d.* net.]

NOTES.

THE ENGINEERING INDUSTRY AND THE EXPORT POSITION.

REVIEWING the latest export and production figures at a Press conference on Thursday, March 4, the Chancellor of the Exchequer (the Rt. Hon. Sir Stafford Cripps, M.P.) said that there were no grounds for complacency, and the clear need during the coming year was for greatly increased effort. As a nation, however, we were producing more than ever before; during January, the value of our exports had risen to 124,900,000*l*. On a volume basis this was 28 per cent. above pre-war figures. The value and quantity of the machinery exported in the same month—19,400,000*l*. and 69,601 tons, respectively—constituted a record, the quantity being 80 per cent. higher than in 1938. The number of motor cars exported in January—14,953—was also a record. Encouraging as these figures were, however, they did not reach the targets set and even greater efforts were, therefore, necessary. Continuing, Sir Stafford said that the main limiting factor in the production drive this year would be steel, in spite of the fact that the output during January had been at the rate of 14,600,000 tons per annum, and during the first three weeks in February had risen above an annual rate of 15,000,000 tons. Current production in the engineering industry was encouraging, but this also was limited by the quantity of steel available. Dealing with the situation generally, he remarked that many citizens still did not grasp why it was that last year the deficit in our current balance of payments was so heavy, although we had imported a quarter less and exported rather more than we did before the war. One of the reasons was the change in price levels. This accounted for about 60 per cent. of the total worsening in our position, while the physical and financial losses due to the war, together with increased Government expenditure arising out of post-war liabilities, were the cause of the remainder. Except to some extent for the last named factor, these matters were outside our control and could not be remedied at once.

THE INSTITUTION OF MECHANICAL ENGINEERS.

At a meeting of the Institution of Mechanical Engineers held on Friday, March 5, with Major W. Gregson, M.Sc., President-elect, in the chair, a paper on "Wave Action Following Sudden Release of Compressed Gas from a Cylinder," was presented by Professor G. F. Mucklow, D.Sc., and Dr. F. K. Bannister. In the experiments, which were undertaken at Birmingham University, compressed air contained in a cylinder was discharged suddenly into a pipe, the resulting fluctuations of pressure being recorded at several points along the cylinder and pipe. The air was contained by a cellophane membrane clamped between the cylinder and pipe, and released by the shattering of the membrane when pierced by a needle. Two cylinders were used for the main trials; both 2-in. bore, one 8 ft. long and the other 40 ft. 6 in. in length. In most cases, the discharge pipes were of 2-in. bore, and 81 ft. in length. A series of trials was also carried out with a cylinder 4 ft. in length and of 4-in. bore, with a pipe 2 in. in diameter. The air pressures ranged from 140 lb. per square inch (gauge) to a 25-in. vacuum. The pressure indicators were mechanical devices, comprising a diaphragm, with a maximum deflection of 0·002 in. corresponding to an indicated ordinate of 2½ in., a stainless-steel mirror operated by a pin from the diaphragm, and an optical system. The first half of the paper dealt with the theory of the phenomena. Several established theories were examined and extended to apply to the experiments. The results of the trials, including indicator diagrams, were given in the second half of the paper, and it was concluded that the processes of discharge from a cylinder into a pipe, or to the atmosphere, might be explained fully by extending the accepted physical laws of the propagation of waves of finite amplitude in pipes. An explanation by sound-wave theory was unsatisfactory if the cylinder pressure were appreciable. For a vessel discharging to atmosphere through an orifice of smaller diameter, the processes were substantially as described by Professor E. Giffen, D.Sc., Ph.D., M.I.Mech.E. (see ENGINEERING, vol. 150, page 134, 1940), the final depression being transient. When a pipe was fitted, the depression was delayed, and its amplitude and duration were increased.

CROWN AGENTS FOR THE COLONIES.

The engineering departments of the Crown Agents for the Colonies, 4, Millbank, Westminster, London, S.W.1, were reorganised on February 16. This was due partly to the desirability of introducing a more logical organisation, in which the several classes of engineers would be confined to their own types of work, and partly to the increase in the scope and amount of work undertaken by the departments. As is well known, the part played by the Colonies in providing food and raw materials for this country is now more important than ever, and the ground-nut and other schemes are intended to increase production. The engineering departments of the Crown Agents are engaged on these developments, in addition to the civil and mechanical branches of railways, the construction and maintenance of docks and harbours, and many other branches of engineering. Previously, there were the designs department, which embraced civil and mechanical engineering, the contracts department, and the engineering inspection department. Under the new organisation, there is an Engineer-in-Chief, and three departments—civil engineering, mechanical engineering (including an electrical branch), and engineering inspection. Mr. W. L. Watson, C.B.E., A.M.I.C.E., has been appointed Engineer-in-Chief, but he will be succeeded in a year's time, when he is due to retire, by Mr. R. W. Foxlee, C.B.E., M.I.C.E., who is at present chief civil engineer. Mr. S. J. W. Gooch, M.I.C.E., deputy chief civil engineer, will then take Mr. Foxlee's place. Mr. A. Campbell, M.I.Mech.E., is chief mechanical engineer, and his deputy and officer-in-charge of the electrical branch is Mr. A. W. H. Keen, B.Sc., A.M.I.E.E. The chief inspecting engineer is Mr. J. W. Norris, A.C.G.I., A.M.I.C.E., A.M.I.Mech.E.

CAPPER-PASS AWARDS IN METALLURGY.

In order to encourage the presentation, to the Institution of Mining and Metallurgy, of papers on processes and plant used in extraction metallurgy, and the submission, to the Institute of Metals, of papers on methods and equipment employed in the fabrication of non-ferrous metals, the directors of Messrs. Capper, Pass and Son, Limited, Bristol, have offered to these institutions the sum of 200*l*. per annum for a period of seven years. They direct that 100*l*. per annum be available for one or more awards to the authors of papers on some aspect of non-ferrous extraction metallurgy and that the remaining 100*l*. per annum be available for one or more awards to the authors of papers relating to some process or plant used in the extraction or fabrication of non-ferrous metals. The authors, in all cases, should be persons engaged full-time in industry or practice. The Councils of the Institution of Mining and Metallurgy and of the Institute of Metals have accepted the offer and have appointed a joint adjudicating committee. The Councils of the two Institutions hope that the offer of these awards will stimulate the writing of many papers of the types envisaged by Messrs. Capper, Pass and Son. It is pointed out that papers on extraction metallurgy should be submitted preferably to the Institution of Mining and Metallurgy, while those dealing with fabrication processes should be offered to the Institute of Metals. Both societies are prepared to accept papers of suitable quality from non-members. Authors are asked to note that applications should not be addressed to the adjudicating committee; all papers published by both societies will be examined by the committee annually and notices of any awards decided upon will be published in the journals of the two societies and also in the Press. The committee will consider, in due course, all papers published by the two societies during 1948, and may, at their discretion, make no award or awards of less than the sums available if, in their opinion, the quality or number of the papers submitted fails to reach a suitable standard.

LETTERS TO THE EDITOR.

TESTS OF 4-4-4-4 PASSENGER LOCOMOTIVE, PENNSYLVANIA RAILROAD.

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. Poultney's article, on page 193 of your issue of February 27, 1948, is a most interesting and valuable record of steam locomotive performance at high speed. It demonstrates again that, given adequate port openings, the reciprocating engine can use effectively large quantities of steam at speeds up to 7 r.p.s., and that it is practicable to build locomotives that can utilise their full boiler output at any speed likely to be needed in actual service.

As a yardstick of overall efficiency, the coal consumption per drawbar horse-power hour is the most significant of normally available figures (failing efficiency as a percentage, which is not often quoted for locomotives, presumably because it looks so depressingly low) and it is given in the penultimate paragraph of the article as 2·5 lb. to 3·5 lb. Figures near the low end of this rather wide range would be extremely gratifying, but, unfortunately, the test results in Tables II and III do not confirm them. Even the weight of coal per indicated horse-power hour ranges from 2·8 lb. to 3·6 lb.

As Mr. Poultney points out, the drawbar horse-power developed on a track test would be lower than that recorded on the test plant. Rough calculation suggests that at speeds higher than about 60 m.p.h. the differences between indicated horse-power and drawbar horse-power would probably be about twice those shown in Fig. 5. On this basis and the figures in Tables II and III, the coal consumed per drawbar horse-power hour on the track would range from 3 lb. to 5 lb. In this country, modern locomotives in pre-war condition burned 2·8 lb. to 3 lb. of coal per drawbar horse-power hour on test and 3 lb. to 3·2 lb. in normal service. On test, as far back as 1933, the Chapelon 4-8-0 gave figures ranging from 2·4 lb. to 3 lb. per drawbar horse-power hour. At a driving wheel speed of 370 r.p.m. (88 m.p.h.), the T1 developed 6,600 indicated horse-power, *i.e.*, 30 indicated horse-power per ton of locomotive weight, or 72 indicated horse-power per square foot of grate area. At the same rotational speed the Chapelon 4-8-0 developed 39 indicated horse-power per ton, or 100 indicated horse-power per square foot, so that the American locomotive is far from breaking records in these respects.

Overall operating efficiency, however, is more important than fuel economy or high power alone, and it is therefore interesting to note that service results have been good enough to warrant the building of fifty of these locomotives. This suggests that it would be practicable in Great Britain to haul 500 tons at 100 m.p.h. on the level by means of a steam locomotive weighing about 105 tons. It would be desirable, however, to find a way of doing it with fewer than eight valves per cylinder. One wonders why relatively small cylinders were employed in the T1. Such moderate dimensions (by American standards) as 23 in. diameter and 28 in. stroke would have permitted the working pressure to be 210 lb. per square inch instead of 300 lb., with marked reduction in weight and maintenance cost of the boiler.

Yours faithfully,
W. A. TUPLIN, D.Sc., M.I.Mech.E.
390, Wakefield Road,
Huddersfield.
March 5, 1948.

PETER WILLANS.

TO THE EDITOR OF ENGINEERING.

SIR,—It was on March 13, 1888, just 60 years ago, that Peter Willans read his paper, "Some Trials of a Non-Condensing Steam Engine," before the Institution of Civil Engineers; and, reading again through it and the discussion which followed it (it occupied three full sessions of the Institution), one realises, perhaps more clearly than was possible at the time, what an outstanding event it was.

It was well known that there were losses in the

steam engine, not accounted for by the indicator diagram, but never before had anyone set out to discover why and where they occurred and any possible remedy for them, though there was no lack of theories on the subject. Never before had anyone laid out a testing plant, each detail of which could be checked by independent observers, and carried out a series of tests entailing months of careful and costly work under such conditions that not a single criticism could be raised as to the methods employed or the accuracy of the results obtained; with the possible exception of the gentleman who said that it would have been better if the results had been given in cwt. of coal instead of in lb. of water.

One has only to read the names of those who took part in the discussion and the subsequent correspondence to realise what an almost world-wide interest was aroused. Nearly every prominent engineer in this country and many from abroad welcomed the paper and, with very few exceptions, complimented the author on his work and the results. Even Isherwood, the Chief Engineer of the United States Navy at the time, whose communication occupies 22 pages of the *Proceedings*, though critical of some of the author's deductions, was highly complimentary on the methods adopted, the care and accuracy with which the tests had been carried out, and the value of the paper as a whole. This was the predominant note of the whole discussion and correspondence: high praise for the author who had conceived and carried out such an exhaustive series of tests, and of the accuracy and value of the results coupled with criticisms of some of his deductions.

One of the main points of criticism was the standard he had chosen with which to compare the performance of the actual engine, and it is amusing to read how many and diverse were the opinions of the engineers, professors, and scientists as to the correct formula to be adopted. So lucid and convincing was Willans's reply, however, both verbal and communicated, that one is led to believe that even the critics themselves must have realised that he was right. MacFarlane Gray, perhaps the greatest authority of them all on the subject, completely endorsed his views.

Willans started work immediately on the companion paper—"Trials of a Condensing Steam Engine," but in November of that year his works at Thames Ditton were completely destroyed by fire, and it was not until the new works had been completed in the autumn of 1889 that he was able to resume this series of tests. He took advantage of the clean slate wiped by the fire to lay out the new testing plant—and, indeed, the whole new works—on a novel and original plan. The testing plant was certainly the first of its kind in this country and probably the first in the world. Its primary object was to ensure that every engine, before it left the works, should be given a thorough test under steam for efficiency and consumption, but it also allowed for the continuance of his experimental work without interference with the routine testing of the works output. The chief innovation in this plant was that, instead of weighing the water into the boiler—a system which, under the most favourable conditions, entailed a test of some hours duration—he weighed the condensate from the exhaust, so that, provided that the load was steady, the consumption at any given load could be ascertained accurately in half an hour. He also installed the most accurate instruments then available for measuring the electrical load, so that, when testing combined sets (engine direct-coupled to dynamo) the performance of both parts of the set could be ascertained.

It was my privilege that Willans agreed to take me as a personal pupil, though I doubt whether I realised my great good fortune at the time. I joined him at the beginning of September, 1888, and was with him at the time of the fire and during the building and reorganisation of the new works. After I had been through the various shops, he took me on to the test-bed for the last six months of my time and kept me there afterwards as a junior member of the staff. It was there that I first came under his personal supervision, and assisted in a very minor capacity in some of the trials for the second paper. At the time of Willans's death, early in 1892, this second paper was not quite complete; but the work was carried on by his partners and eventually the paper was read by Mark Robinson on April 11, 1893. It did not provoke the same amount of discussion as the first paper—indeed, there was little to discuss—but from it arose the unanimous agreement of the meeting that the "Straight-Line Law" of steam-engine consumption which Willans had evolved should be known thereafter as the "Willans Law." In this discussion, Professor A. B. W. Kennedy bore witness to the great value of the "Willans Law" and showed how it applied not only to the steam engine but to the gas engine and other forms of prime mover, even to the Parsons turbine, which, at the time, was just emerging from its infancy.

These two papers bear striking testimony to Willans's eminence as a practical and scientific engineer, but they do not tell the whole story of his achievements. There can have been very few engineers who have accomplished so much in such a short life. He was 41 when he died, so that his working life can have been little more than 23 or 24 years, yet in that short space of time he had invented and brought into production his launch engine and his central-valve engine; he had shown that comparatively heavy engineering work could be successfully undertaken on mass-production lines, both technically and commercially; he had instituted a system of working to fine limits which is scarcely surpassed by any engineering works to-day, and he had founded a business which was largely instrumental in the development of the electricity supply industry. The extent to which this last was the case can be judged by the fact that, 12 years after his death, 75 per cent. of the electricity developed in in London, and over 60 per cent. of that in the United Kingdom, was generated by Willans engines, and there was scarcely a country in the world in which they were not used. The performances of many of these engines were notable; for instance, about 1889 a two-crank compound engine, of 80 h.p., at 450 r.p.m., was supplied to the Elmore Copper Depositing Company of Leeds, and ran continuously day and night for over 13 months. When it was shut down so that some alterations could be made to the plant, the management asked us to overhaul it before starting again on a similar run. We stripped it down to the bedplate and carefully checked the wearing parts, finding that there was no appreciable wear. It was re-erected without any alterations or replacements and, I believe, continued to do good service for many years. In 1887, a 50-h.p. engine, coupled to a Holmes dynamo, was supplied to Messrs. Maple and Company, Tottenham Court-road, London, and I understand that this set is still in regular use.

Yours faithfully,

E. S. Ormsby, M.I.Mech.E.

40, Grosvenor-gardens,
London, S.W.1.

COUNCIL ELECTIONS IN PROFESSIONAL INSTITUTIONS.

To the Editor of Engineering.

Sir,—At a time when the position of professional men in society comes under public discussion, and the status of a profession is the subject of a vote, the various methods of collating, analysing and summarising wishes and opinions have a wider importance even than the analysis of technical data in the ordinary course of professional work. Engineers, in particular, are familiar with the statistical methods employed in establishing the proportions and averages required either for the solution of problems in research or by technicians in the performance of routine duty. The data in these cases, however, are seldom comparable, either in variety with the shades of opinion that voters must often vainly desire to express, or in complication with the conditional assumptions usually inherent in an expression of opinion. To overcome these difficulties, the most efficient means of establishing and expressing a collective wish or opinion is seen to be a requirement not only of the medical profession, but equally of every club, trade union and professional body.

Various methods from the earliest times have been employed for this purpose, and they conveniently fall under one or other of two heads, namely, direct and indirect representation. In the former case, two practices are equally possible and, perhaps, are of equally long standing: either a question, or list of questions, can be put to the voters who must each answer with simple assent or dissent; or else a proposition can be put to the voters as a body, discussed, perhaps amended, and then put to the vote. The one is that of the plebiscite or Gallup poll; the other, that of a deliberative assembly. However, in its Latin origin the word "vote" means only to wish, and in it an expression of objective opinion is not necessarily implied, either in theory or in practice.

Among small groups of individuals, the deliberative method has been used successfully in this and other countries at least from the days of the Saxon folk-mote, and it affords the most obvious and easiest way of obtaining the completest statement most willingly supported by the greatest number; since it enables "the sense of the meeting" to be tested effectively by differentiation, before any conclusion is expressed. It also obviates the use of false alternatives to which the voter, asked to choose A or B, is often subjected. It is free from the simple "yes-and-no" method, which only becomes more complex, the more a true and full expression is sought. It may be remarked that a Ministry of Works form numbered 6662, dated October 29, 1947, and still in use, asks housewives 392 questions on 11 pages, of which the question numbered 9J is, whether the housewife finds it easier to shut the oven door by hand, foot lever, neither, or both. In dealing with large or geographically scattered groups of individuals, however, the deliberative method is slow and costly in correspondence, and there is something to be said therefore in favour of the questionnaire. The only alternative free from the objections to these, in such cases, is found in the adoption of indirect representation.

With the use of this device, all hope of mathematical exactitude in representing the individual must be abandoned. Two systems are in common use: those of delegation, whereby "legates," as they have sometimes been called, go with fixed instructions to vote in central delegate assembly as nearly as can be done to the will expressed in a local assembly; and those of representation in a looser sense, whereby chosen speakers plead in a central representative assembly the cause of their constituents. The former system is commonly used in trade-union management, but the status and obligations of the councillors of a society, institution or body politic are matters for decision by the electors in each case. In both systems, a usual tendency to contest elections affords evidence that, in practice, the elector feels the need to trust either "delegate" or "representative," and desires to elect an individual of known quality. Indirect representation thus introduces a totally different conception of voting; it is not for an action, but for a person, as indicated by the classical derivation of "suffrage," in the sense of "support" for a person.

The election of representatives is increasingly a world-problem. It was investigated by writers such as J. S. Mill and Thomas Hare in the past century, and historians of the East inform us that even the predecessors of Attila were, by long custom, elected among the Huns in the tumultuous assembly of their Corultai. But particular interest is centred on modern practice by a recent alteration in method adopted by a professional body in this country, namely, the Institution of Naval Architects, following a similar course to that of the Cotton and Rayon Merchants' Association.

Where the candidates for election are relatively few, the simplest means by which the elector can express his full wish is, knowing the candidates and their views, to number them in order of his preference. The number of voters is then divided by the number of seats in the representative assembly, and the result is the "quota." Any candidate obtaining the full quota is elected on the first count, any ballot papers in his favour over and above the number of the quota being discounted as regards him and transferred to the candidate numbered on those

papers next in order of the voter's preference. By this means, excessive votes are not wasted, but are used to make up the quota for another candidate. Similarly, papers numbering first this other candidate are not wasted, or the voters frustrated, through there being not enough "first preferences" for him. Quotas are made up with second, third and fourth preferences, and so on; so that, in the ideal case, no vote is wasted, and no candidate is elected without the full quota of electors supporting him at least as an alternative choice. It will readily be seen that, where the electors happen to award their higher preferences to relatively well-approved candidates and to sufficient of them to fill the vacant seats, few will fail to obtain high-preference representatives. This method of election, giving proportional representation with the single transferable vote, is that now chosen by the Institution of Naval Architects. It is in political use in Eire, Tasmania, and elsewhere, and was described in the House of Commons by Mr. Churchill, in 1931, as being by far the most scientific, fairest, and best in the general interest. Fuller description of its principles and effect are shown from different points of view in *Parliamentary Representation*, by J. F. S. Ross, *Coupon or Free*, by R. W. G. Mackay, and *Happiness by Experiment*, by the present writer, and the elections of many governing bodies in this country are now carried out by personnel long familiar with the procedure. The services of an independent organisation are used for this purpose, and are available either for giving advice or for carrying out an entire election.

Yours faithfully,

82, Victoria-street, MICHAEL BIRKIN.
London, S.W.1.
March 4, 1948.

OBITUARY.

MAJOR H. P. M. BEAMES, C.B.E.

WE regret to record the death on Friday, March 5, of Major H. P. M. Beames, C.B.E., at his home at Chester Place, Crewe. Major Beames was the last chief mechanical engineer of the London and North Western Railway; but he is best remembered as the re-organiser of Crewe locomotive works.

Hewitt Pearson Montague Beames was born on May 9, 1875, and was educated at Dublin. F. W. Webb was the chief mechanical engineer of the London and North Western Railway at Crewe when Mr. Beames entered the works as a premium apprentice in January, 1895. He was junior assistant to the works manager at Crewe for a few months, before volunteering for service in the South African War. In 1901, Mr. Beames returned to Crewe. From December of that year to December, 1909, he was assistant to the Superintendent, Outdoor Department. The first major engineering work for which he was responsible was the introduction of plant for the mechanical handling of coal from wagons to locomotive tenders. In 1914, Mr. Beames was given command of the 110th Company (Railway), Royal Engineers, and served as a Captain, R.E., in the B.E.F., until March, 1916, when he was seconded to Crewe as works manager and chief assistant to the C.M.E. In this capacity, he was responsible for the production of munitions at Crewe. When officially released from military service in 1919, he was appointed deputy chief mechanical engineer, L.N.W.R., and a year later, in December, 1920, he succeeded Mr. C. J. Bowen-Cooke as chief mechanical engineer. In January, 1923, he became Mechanical Engineer, Crewe. From 1925 to 1927, he undertook the re-organisation of Crewe locomotive works, reducing the time required for repairing a locomotive from three months to 47½ working hours. In 1931, he was appointed deputy C.M.E., L.M.S. Railway, from which position he retired in September, 1934. Major Beames was a member of the Institution of Civil Engineers, a member of the Institution of Mechanical Engineers, and a vice-president of the Institution of Locomotive Engineers. In the New Year Honours List for 1946 he was made a C.B.E.

THE ENGINEERING OUTLOOK.

XI.—MARINE ENGINEERING AND SHIPBUILDING.

A YEAR ago, prospects for British shipbuilding were probably brighter than at any time during the industry's long history. At the end of 1946, merchant tonnage on order totalled some 3,000,000 gross tons and orders were flowing in at an increasing rate. During the first quarter of 1947, a further 500,000 tons were added to the industry's order books, and when, in February, the Government described the restoration of the British merchant fleet as one of the major tasks ahead, it was generally considered that 1947 would be a boom year for British shipbuilding. Only the labour situation appeared unsatisfactory to shipbuilders, who feared that the introduction of the five-day week would lead to serious output losses and increased costs. The Government's policy, stated in the White Paper, *Economic Survey for* 1947, was most encouraging: "The merchant fleet under British ownership is 13·9 million gross tons, compared with 17·4 million gross tons at the beginning of the war. . . . Previously the fleet was a significant earner of foreign exchange; other countries paid us more for carrying their imports than we paid them for carrying ours. . . . Therefore we must build more ships. The shipbuilding industry is just of the same importance as an earner of foreign exchange as an industry producing entirely for export. Last year it produced nearly 1 million gross tons of ships—about the same as in 1938. The target for 1947, achievement of which depends upon the increased output per man year and upon adequate supplies of materials and fittings and other components, is 1¼ million gross tons with a large repair programme in addition."

The industry itself felt that, given the necessary materials and equipment, this target could be exceeded by at least 250,000 tons. Unfortunately, the Government were unable to grant the industry or its suppliers any priority in the allocation of steel, timber, plywood and other materials. The tonnage completed during the year totalled 950,000 gross tons, 24 per cent. less than the target set by the Government. The tonnage launched during the year was 1,207,000 gross tons. The returns issued by Lloyd's Register during the year show figures of 270,000 tons for the first quarter, 244,000 for the second, 302,000 for the third, and 391,000 for the fourth. The high figure for the last quarter doubtless reflects the improvement of steel deliveries in the latter half of the year. On the whole, the figure for tonnage completed during 1947 was far higher than was expected by the Government, whose estimates, presumably based on steel allocation figures, ranged from 750,000 to 800,000 tons.* The official explanation is that the industry received substantially more steel than it was allocated, being one of the few industries to benefit from the breakdown of the Government's allocation system.

Throughout 1947, shipbuilders displayed considerable anxiety concerning the future availability of steel. This arose largely from the Government's pronouncement after the fuel crisis last winter, which indicated that priorities in steel allocations were restricted to programmes directly concerned with the production of fuel and power, and failed to recognise the importance of the shipbuilding industry's requirements. It would appear, however, that planned allocations had little effect on steel deliveries, simply because the steel mills which were producing the qualities of steel required by shipbuilding yards went on doing so to the full extent permitted by their supplies of coal and raw materials. Moreover, no one knows exactly the stocks held by the shipbuilders, or by their suppliers of fittings and components. The nervousness of the industry can be readily understood, however, since it is of the utmost importance that it should be able to plan ahead with confidence; any disruption in the continuity of supplies would have a disastrous effect on costs and on the morale of the labour employed in the industry.

Most of the shipbuilders' difficulties during 1947 centred on the completion of ships once launched, and, in the main, were due to acute shortages of hardwood, plywood, fittings and certain components and ancillary equipment, such as electric motors, brass locks and hinges for cabins, etc. The shortage of timber was made worse by the Government's allocation methods, which the industry found most irritating. A shipbuilder cannot acquire the timber for decking purposes till ten days before the vessel is to be launched. The timber, when received, is often found to be unseasoned and of poor quality, and has to be sent for treatment, as adequate facilities for reducing the moisture content are not readily available on the spot. In consequence, delays in fitting out ships have steadily increased. This is borne out by the high figure of 2,173,361 gross tons for merchant shipping under construction at the end of the year. This is the highest for 25 years, and Lloyd's Register comments that the increase "is necessarily influenced by the delays which present circumstances are imposing on the completion of ships, and the consequent prolongation of the time required for building them."

The chairmen of several shipbuilding companies reviewed the difficulties experienced in the past year at their annual meetings. Dr. E. P. Andreae, chairman of Messrs. William Doxford and Sons, Limited, stated in November:—"Any large building contract, whether in ours or any other industry, has to be calculated on time schedules if it is to be economic. In the circumstances, however, shortages have made it impossible to maintain the proper sequences of operations, which is the essence of good planning. Also, through diversion of their output to other priorities, sub-contractors have in many cases not been able to supply our requirements at the time necessary to suit our programme, and the lack of quite minor parts has often caused disproportionately great delays and increases in the cost of both ships and engines."

The problem of rising costs is probably the most serious the industry will have to face during the current year. Building costs rose sharply during 1947, and there is increasing evidence that they are now approaching the level beyond which owners can see little reasonable hope of earning the adequate capital investment for shipping tonnage. There have been several warnings from shipowners that rising costs and the uncertainty of delivery dates would soon justify deferment of the placing of orders. Mr. I. C. Geddes, chairman of the Orient Steam Navigation Company, speaking at the launch of the liner Orcades, announced that another ship would be laid down on the vacated berth, but complained of "uncertain timing for delivery and frighteningly high costs." He pointed out that the two ships would cost more than 6*l.* million, an increase of some 2½ times on the cost of corresponding ships before the war. Apart from covering running costs far in excess of pre-war levels, each ship will have to earn about 300,000*l.* a year to cover interest and depreciation. Mr. Geddes said that the faster speed of the ships should make possible four round voyages a year, instead of three, and that his company were widening the range of accommodation in the first class, hoping that many who previously travelled tourist class would transfer to the first class. His hopes, however, were not shared by every shipowner.

Mr. Cyril Dewey, speaking for the Blue Star Line at the launch in November of the Uruguay Star, one of the four passenger and cargo liners now being built by Cammell Laird and Company for service between the United Kingdom and South America, pointed out that his company could not gain the full advantage of faster ships because of the slower working in ports. A big impression was made in shipbuilding circles by the negative results of a visit in the same month of Mr. William Neal, chairman of Canadian Pacific Steamships, Limited, who was known to be considering the placing of contracts for new passenger liners to replace war losses. Mr. Neal left the Clyde after publicly stating that the costs were too high, despite the urgency of his company's needs. He

* The steel allocation figures for the year are not available, but on the basis of allocations for the second and third quarter, mentioned in a report published in August by the Confederation of the Shipbuilding and Engineering Unions, the industry was allocated some 670,000 tons of steel.

returned to Canada without placing the expected contract, although it is understood that negotiations are continuing.

At the end of last year, it was reported from Scottish yards that a British company had cancelled a 2·75*l.* million contract for three ships, because delivery dates were so uncertain and final prices could not even be guessed. Two foreign firms took similar action, and some well-known British companies have indicated that their building programmes would be reconsidered on account of rising costs and delays in delivery. This nervousness on the part of operators is doubtless due to a fear that the present buoyancy of freights and cargoes and the high level of passenger traffic will not be maintained. Such doubts, although largely speculative, cannot be easily dismissed; and it is evident that, unless shipowners can amortise their capital invested at the present inflated rates during a period of corresponding inflation of freight and passenger rates, they will incur serious losses. This applies particularly to tramp ship owners, whose orders for cargo vessels are likely to provide the bread and butter of shipbuilding when the present urgent replacements for specialised tonnage have been satisfied. These owners are not likely to place contracts until they have evidence that freight levels are likely to maintain, over a period of years, a reasonable relationship to current building costs. It remains to be seen, however, whether shipbuilders can reduce or effectively prevent any further increase in building costs. They themselves recognise the force of the owners' arguments, but have no control over some two-thirds of the total cost of a ship. This depends on the prices of materials, sub-assemblies and equipment, which have to be obtained in the face of competitive demand from other engineering industries. The recent increase in the price of coal, for example, has been followed by a consequent advance in the cost of steel plates and angles, and this process is reflected in almost every item of a ship's structure. Other most important factors in building costs, such as full-capacity production, and high productivity of labour, are seriously threatened by the prospect of diminishing supplies of materials. The fact that the industry has found it necessary recently to abolish payment by results is an indication that the problem of under-production is already facing certain shipbuilders, with inevitable adverse effects on costs.

The Government's financial assistance to shipowners was commented upon by Sir William Crawford Currie at the annual meeting of the Peninsular and Oriental Steam Navigation Company, on December 17, 1947. Sir William pointed out that the official allowances under the Income Tax Act, 1945, were simply an advance instalment of the wear-and-tear allowances which would normally accrue between the sixteenth and twentieth years of a ship's life and were not, as was sometimes supposed, some form of free gift from the Exchequer. Sir William emphasised that this has not in any way helped to make "an economic unit out of an expensive ship." These allowances were granted to assist in making good the omission during the war years of depreciation allocations of the scale necessary to replace tonnage. He also referred to a suggestion that the Government Tonnage Replacement Account could be used to offset the present cost of tonnage, and stated that this reserve would not be used for writing down costs until it was known at what level the cost of new construction was likely to be stabilised. It was the intention of his company to write down the cost of more expensive ships to that level by applying this reserve, but only if a lower level of building costs is realised. In the meantime, the company will follow the principle of allowing for depreciation on the full cost of construction. Sir William revealed that the cost of the latest ships now building was in the region of 110*l.* per ton, compared with the 48*l.* per ton average for ships delivered between 1937 and 1938, and that the cost of dry-cargo liners, which averaged 12*l.* to 15*l.* per gross registered ton in 1915, had risen to 30*l.* to 36*l.* just after 1920, and was at the present time between 55*l.* and 66*l.*

Details of merchant-ship building, repair, conversion and reconversion, published in the *Monthly Digest of Statistics* for January, 1948, are given in Table I, herewith. This Table includes merchant-type vessels building for the Navy. The quantity of such shipping completed was as follows: in 1941, 4,000 gross tons non-tanker (all of 100 to 1,599 tons gross) and 20,000 gross tons tanker (all of over 1,600 tons gross); in 1942, 8,000 gross tons (all non-tankers of 100 to 1,599 tons gross); and, in 1943, 1,000 gross tons tanker and 63,000 gross tons non-tanker. During 1947, the ships completed totalled 948,000 gross tons, compared with slightly less than 1 million gross tons in 1946 and slightly more than 1 million gross tons in 1938. The monthly figures shown in Table I reflect the serious interference of the fuel crisis and the bad weather last winter, the drop in completed tonnage in February persisting until the end of May. The tonnage laid down during 1947 totalled 1,032,000 gross tons; 96,000 tons less than during the previous year, but more than twice that laid down in 1938. The increase in the tonnage under construction, from 1·76 million gross tons at the end of 1946 to 1·95 million tons, reflects the growing delays in fitting out the hulls.

The figures relating to ships of 1,600 gross tons and over are shown separately for tankers and non-tankers. The tonnage for tankers completed during 1947, 120,000 gross tons, represents a considerable fall on the previous year's figure of 312,000 tons; but the tonnage laid down shows an increase from 216,000 in 1946 to 288,000 in 1947, and the tonnage of tankers under construction increased by 160,000 tons, to 421,000 tons at the end of 1947. This is by far the highest figure recorded, and suggests a high figure for completed tonnage during the current year.

Tonnage undergoing repair, conversion or reconversion, shown in Table I, includes shipping undergoing routine survey and repair. Much of it makes little demand on the workers in heavy steel, but it absorbs a great amount of the time of the finishing trades. The complete refitting of the Queen Elizabeth and the Mauretania was executed in seven months, and these ships are now earning valuable dollars on the North Atlantic "hard currency" route. Details published in *The Times* of January 17 show that, by March last year, conversion in the shipyards had reached its maximum. Five ships, representing 163,000 tons, had been completed, and work was proceeding on 36 ships, of 665,000 tons. By the end of the year, 31 ships, totalling 617,000 tons, had been refitted, and work was in progress on 28 others, of 412,000 tons. A start had yet to be made on 11 ships, of 225,000 tons. It has been estimated that, by March, 1949, at the present rate of progress, about 97 per cent. of the work should have been done. All 70 vessels, representing more than 1·25 million gross tons, including 61 large passenger liners and nine passenger and cargo liners, should be refitted by September, 1949. This means that, until that date, labour which otherwise would be idle through late deliveries of components and fittings for new ships can be usefully employed on reconversion work.

Details of launchings during 1947 are given in Lloyd's Register's annual summary of shipbuilding

TABLE I.—MERCHANT SHIP BUILDING, REPAIR, CONVERSION AND RE-CONVERSION IN THE UNITED KINGDOM.

(*Thousand Gross Tons.*)

	All Vessels of 100 Gross Tons and over.			1,600 Gross Tons and over.						Undergoing Repair, Conversion or Reconversion in U.K. Ports at End of Period.*
				Non-Tankers.			Tankers.			
	Laid Down.	Under Construction at End of Period.	Completed.	Laid Down.	Under Construction at End of Period.	Completed.	Laid Down.	Under Construction at End of Period.	Completed.	
1938†	42‡§	780	86‡‖	—	—	—	—	—	—	—
1939†	84‡§	1,003	52‡‖	—	—	—	—	—	—	—
1940	88‡	1,160	67‡	65‡	813	62‡	20‡	318	3‡	—
1941	102‡	1,226	96‡	77‡	884	71‡	22‡	317	23‡	—
1942	112‡	1,270	108‡	89‡	1,006	80‡	19‡	237	26‡	—
1943	82‡	1,055	100‡	61‡	788	80‡	18‡	239	17‡	2,287
1944	78‡	995	85‡	55‡	680	65‡	17‡	267	15‡	2,576
1945	101‡	1,465	62‡	71‡	1,047	41‡	22‡	354	15‡	3,182
1946	107‡	1,763	82‡	83‡	1,446	50‡	18‡	251	26‡	3,100
1947 (total)	94‡	1,951	79‡	63‡	1,429	64‡	24‡	421	10‡	3,396
1947, January	122	1,802	88	98	1,455	77	16	256	9	3,294
February	20	1,768	54	16	1,438	33	—	237	19	3,310
March	105	1,807	66	75	1,466	47	26	248	15	3,455
April	85	1,835	57	64	1,478	52	13	261	—	3,535
May	87	1,870	52	55	1,500	33	26	272	15	3,501
June	123	1,871	122	76	1,465	111	32	299	5	3,354
July	84	1,884	71	56	1,466	55	20	310	9	3,317
August	84	1,892	76	61	1,465	62	20	321	9	3,256
September	104	1,913	83	76	1,462	79	25	346	—	3,370
October	126	1,942	97	72	1,472	62	49	368	27	3,391
November	86	1,972	56	40	1,464	48	40	408	—	3,268
December	105	1,951	126	73	1,429	108	24	421	11	3,396

* Including troop transport and hospital ships, and naval and military supply and service ships, other than H.M. commissioned ships and Royal Fleet Auxiliaries.

† These figures have been taken from the returns of Lloyd's Register and are not strictly comparable with the figures shown in the rest of the Table; they relate to the United Kingdom and Eire, and include certain non-propelled lighters, etc.

‡ Monthly averages. § Commenced. ‖ Launched.

TABLE II.—MERCHANT VESSELS UNDER CONSTRUCTION IN BRITISH SHIPYARDS.

	At December 31, 1947.		At September 30, 1947.		At December 31, 1946.	
	No.	Gross Tonnage.	No.	Gross Tonnage.	No.	Gross Tonnage.
Steamers:						
Steel	186	980,507	188	976,758	195	997,329
Wood and Composite	—	—	—	—	—	—
Total	186	980,507	188	976,758	195	997,329
Motorships:						
Steel	263	1,181,339	254	1,124,309	224	929,882
Wood and Composite	5	1,136	6	1,198	10	1,646
Total	268	1,182,475	260	1,125,507	234	931,528
Sail and Barges:						
Steel	34	10,379	35	10,404	25	8,205
Wood and Composite	—	—	—	—	—	—
Total	34	10,379	35	10,404	25	8,205
Grand Total	488	2,173,361	483	2,112,669	454	1,937,062

activities, published in February. The total tonnage launched, 1,202,000 gross tons, represents 56·9 per cent. of the world's output for 1947. It compares with an average annual output of 1,185,000 tons for the eight years 1923-30, and of 573,625 tons for the eight years 1931-38. The percentage of the world's output accounted for by British shipyards compares with 53·3 per cent. in 1946, and 34 per cent. in 1938. Launchings included 22 vessels exceeding 10,000 tons each, among which were the 34,000-ton Caronia, built at Clydebank, the 31,000-ton Orcades, built at Barrow, and the 28,500-ton sister ships Edinburgh Castle and Pretoria Castle, built at Belfast. Seventy-eight vessels of between 5,000 tons and 10,000 tons each, comprising 37 steamers and 41 motorships, were also launched. Excluding vessels of less than 1,000 tons, 16 vessels, of 132,661 tons (five steamers and 11 motorships) were launched for the carriage of oil in bulk. The five steamers use oil fuel in their furnaces. Altogether, the total tonnage of steamers fitted for burning oil fuel, launched during the year, amounts to approximately 590,000 tons. The summary states that 36 vessels of 372,690 tons, launched during 1947, were fitted with steam turbines, one of 12,200 tons being fitted with electric drive and the remainder with reduction gearing. In addition to these, 14 vessels, of 59,639 tons, were fitted with a combination of steam reciprocating engines and turbines.

Statistics relating to the number and tonnage of vessels under construction in British shipyards are given in Table II, opposite. These figures, obtained from the shipbuilding returns of Lloyd's Register for the last quarter of 1947, show that the total tonnage under construction at the end of the year, 2,173,361 gross tons, exceeded the corresponding figure for 1946 by 236,299 tons, and has not been exceeded since March, 1922, when the total recorded was 2,235,998 tons. It should be noted that vessels being built at merchant shipbuilding yards to the order of the Admiralty for naval purposes solely are not included in this return; but certain vessels, which are of merchant type (tugs, oil tankers, etc.), but which are intended for naval service, are included. About 30·9 per cent. (671,000 tons) of the tonnage being built is intended for registration abroad or for sale. Work in shipyards abroad (excluding Russia, Germany and Japan) amounted to 1,808,996 gross tons, so that the British share is 55 per cent. of the world total. The busiest countries abroad are France (295,389 gross tons), Sweden (261,605), Holland (255,199) and Italy (219,122), while Canada is working on 148,250 gross tons, compared with only 135,852 tons under construction in the United States. Out of 84 oil tankers, totalling 742,084 gross tons, British yards are building 50, of 447,945 tons. The only vessels larger than 20,000 tons are in British yards; six of them under construction there account for about 190,000 gross tons. Further particulars concerning the sizes of vessels under construction are given in Table III, herewith. Vessels of less than 100 tons are not included in Lloyd's Register.

Lloyd's Register also shows that Norway and France are, at the moment, the largest importers of ships by a considerable margin. The former has 453,000 tons and the latter 233,000 tons building in other countries. Other importers are Portugal (121,000), Argentina (97,000) and Brazil (64,000). Britain remains by far the largest exporter of ships; the total of 671,000 tons building in British yards for foreign account compares with 163,800 tons in Sweden, 133,170 in the Dominions, 129,450 in Italy, and 70,861 in Denmark. As many as 51 ships, totalling 146,832 tons, for foreign account were begun during the last quarter of 1947, bringing the export percentage to 30·9. This proportion is likely to increase still further; a considerable batch of export orders has been received, including ships for Panama and the United States. Orders from Norway are reported to total 94 ships, of 643,000 tons; and orders from the Argentine include four refrigerated motor vessels, of 4,800 gross tons each, which were placed with Cammell Laird and Company. Altogether, during 1947, United Kingdom shipyards received orders aggregating 1,800,000 gross tons, of which tankers accounted for 1,100,000 tons. The industry is now reported to have over 1,000 vessels, totalling some three and three-quarter million gross tons, in various stages of fabrication or on order. At the end of the year, the value of work in progress and on the order books was estimated at some 300*l.* million, one-third for export.

On the basis of the figures quoted above, for work in progress and for orders received, the British shipbuilding industry would appear to be in an extremely healthy position. Certain factors, however, which have emerged during the past few months, may set the industry some difficult problems during the current year. The main problem is stated in the Government White Paper on *Capital Investment in* 1948, so often quoted in this series: "Owing to the steel shortage, it will not be possible to meet in full the stated requirement for the shipbuilding industry for 1948, and in consequence a reduction in the programme of work will be necessary."

Following the publication of the White Paper, it was announced that the deliveries to the industry would be approximately 20 per cent. less than in 1947. This raised a storm of protest from the industry, and it was widely alleged that the cut was made in deference to views held by some influential members of the United States Congress, who considered that shipbuilding in Europe should be severely curtailed in order to make steel available for other more essential uses under the European Economic Recovery Programme. This was officially denied by Sir Stafford Cripps. Mr. Douglas Jay, Economic Secretary to the Treasury, explained in January that, in fact, the allocation for the current year had not been cut down below last year's figure; it would stand, in the first two quarters of 1948, at a level actually higher than the allocation for 1947. He intimated that the Government's policy was to limit supplies, which last year substantially exceeded allocations, to a somewhat lower level, though he believed that fears of any heavy or prolonged unemployment resulting from this were greatly exaggerated; and that more ships were likely to be delivered this year than last.

Mr. Jay restated the Government's shipbuilding policy in the following terms: "Our shipbuilding industry is one of the greatest and most precious of our economic assets, both in the short-term and in the long-term. It would, therefore, continue to be one of the first objectives of Government policy to maintain it in a healthy and thriving condition. But at the moment we are threatened by an acute shortage of steel for all essential purposes. We must allocate more in particular for direct exports in order to secure food in return. Therefore, the present need of shipbuilding must be balanced against other national necessities, and given neither more nor less than its fair share."

A statement in such general terms could not be expected to re-assure the industry. Many shipbuilders criticised the Government's revised steel-allocation system for its lack of elasticity, and prophesied that it would break down. The main criticism was that the new system appeared to ignore the fact that shipbuilders require to know their expected supplies at least twelve months in advance. It is too early to say whether deliveries will actually be less than last year's by one-fifth. The new steel-allocation system, which was the result of a special Committee's study of what the situation required, is likely to be more efficient

TABLE III.—SIZE OF VESSELS UNDER CONSTRUCTION IN BRITISH SHIPYARDS.

Gross Tonnage.	Number. Steam.	Motor.	Sail and Barges.	Gross Tonnage.	Number. Steam.	Motor.	Sail and Barges.
100 and under 500 tons	16	68	27	10,000 and under 12,000 tons	14	23	—
500 „ 1,000 tons	34	17	5	12,000 „ 15,000 tons	7	5	—
1,000 „ 2,000 tons	19	26	2	15,000 „ 20,000 tons	3	4	—
2,000 „ 3,000 tons	19	19	—	20,000 „ 25,000 tons	1	—	—
3,000 „ 4,000 tons	13	13	—	25,000 „ 30,000 tons	2	—	—
4,000 „ 5,000 tons	10	11	—	30,000 „ 40,000 tons	3	—	—
5,000 „ 6,000 tons	13	16	—	40,000 tons and above ..	—	—	—
6,000 „ 8,000 tons	20	29	—				
8,000 „ 10,000 tons	12	37	—	Total	186	268	34

TABLE IV.—ESTIMATED NUMBERS EMPLOYED IN MARINE ENGINEERING AND SHIPBUILDING. (*Thousands.*)

	Marine Engineering. Total.	Males.	Females.	Shipbuilding and Ship-repairing. Total.	Males.	Females.
1939, June	52·2	51·1	1·1	144·7	141·8	2·9
1943, June	88·9	75·8	13·1	272·3	246·7	25·6
1944, June	87·4	73·6	13·8	271·1	243·6	27·5
1945, June	80·5	70·1	10·4	252·3	230·4	21·9
1946, June	72·0	67·1	4·9	229·1	217·6	11·5
December	69·3	65·3	4·0	220·2	210·8	9·4
1947, June	68·1	64·6	3·5	214·7	206·1	8·6
August	67·3	63·8	3·5	214·0	205·5	8·5
October	67·1	63·6	3·5	214·7	206·2	8·5
November	67·6	64·1	3·5	214·8	206·2	8·6

TABLE V.—UNITED KINGDOM: SHIPBUILDING AND MARINE ENGINEERING EXPORTS, 1938 TO 1947.

	1938. Tons.	£1,000.	1939. Tons.	£1,000.	1940. Tons.	£1,000.	1941. Tons.	£1,000.	1942. Tons.	£1,000.	1943. Tons.	£1,000.	1944. Tons.	£1,000.	1945. Tons.	£1,000.	1946. Tons.	£1,000.	1947. Tons.	£1,000.
Ships for breaking up ..	13,002	32	22,772	47	—	—	—	—	—	—	—	—	—	—	—	—	9,342	14	4,400	22
War vessels*	6,967	2,022											—	—	—	—	—	—	—	—
Steam vessels†	134,470	4,063	—	7,034	—	1,231	—	278	—	483	—	76	—	983	14,552	1,165	33,678	2,565	108,015	9,668
Motor vessels†	891	1,959											—	33	553	34	15,518	1,349	94,000	8,639
All other vessels	11,574	447											—	37	581	24	24,673	565	16,470	668
Internal-combustion engines‡	2,661	617	2,206	476	1,190	291	805	246	966	284	772	232	1,153	387	52	23	5,392	1,707	7,592	3,061
Steam reciprocating ..	1,229	151	561	73	160	29	374	55	178	65	156	51	179	62	}	‡	{ 944	260	1,453	382
Turbine	993	234	473	171	718	298	23	12	72	35	112	66	115	40			{ 1,854	837	2,435	1,390
Total ..	171,787	9,525	—	7,801	—	1,849	—	591	—	867	—	425	—	1,542	15,738	1,246	91,401	7,297	234,365	23,830

* Includes machinery and armaments. † Includes hull fittings and machinery. ‡ Not classified separately.

than the old in relating deliveries to allocations. It is probable that, during 1948, the tonnage of shipping completed will exceed the 1947 figure, chiefly because the supply of fittings and equipment required by many hulls has shown signs of some improvement. It should be easier, in fact, not harder, to progress such supplies if the new steel-distribution scheme works well; yet shipbuilders' protests are easy to understand. They are told to concentrate more on finishing tonnage under construction, and to be less concerned about starting new ships; but the labour employed on hull erection cannot be readily transferred to finishing work, and the conversion programme, reviewed in a preceding paragraph, indicated that any surplus labour in the finishing trades was kept busy on refitting liners, etc. Shipbuilders want to keep their platers, drillers and shipwrights working steadily, and to keep all the processes in the industry running concurrently at an even pace.

The Government's objective for shipbuilding "over a period of years," stated in the White Paper on *Capital Investment*, is "to restore the British merchant fleet from its present level of 14½ million gross tons to its pre-war level of 16½ million gross tons. The programme must also permit some replacement of average vessels or of war-time vessels built of inferior materials, which have contributed towards raising the proportion of the fleet laid up for repairs and reconversions to 12½ per cent. (1·8 million gross tons), compared with 8 per cent. in 1939 (1·3 million gross tons). The programme also includes provision for replacements and additions to the fishing fleet."

The drastic reductions in naval construction which are to be made during the current year may have an important effect on releasing materials, labour and capacity for merchant shipbuilding. The Navy Estimates for 1948-49 state that no new tonnage will be laid down this year. Details of the shipbuilding programme are given for the first time since before the war. During 1947, new ships "accepted in H.M. service" comprised eight destroyers—four of the Battle class and four of the slightly smaller Weapon class—and seven submarines of the "A" class. Ships building are two fleet carriers, of which the Eagle is afloat; ten light fleet carriers, of which two still remain to be launched; three cruisers; two destroyers; two frigates, and a few minor craft. An indication of how much new construction has been slowed down is given by the fact that, of the cruisers building, the Defence was launched as long ago as 1944, and the Tiger and Blake towards the end of 1945. Completion work is to be slowed down further this year, and completely stopped on several units now afloat.

The labour situation in the shipbuilding and marine-engineering industries appears to be fairly satisfactory. The estimated numbers employed are shown in Table IV, on page 259, which is taken from the January, 1948, issue of the *Monthly Digest of Statistics*. The shipbuilding labour force declined from 229,000 in June, 1946, to 214,700 in June, 1947, and has remained at this level since then. This compares with 144,700 in 1939, and suggests that further reductions might be made as the amount of work in naval yards decreases. The female labour employed appears to have become stabilised at 8,600, roughly 2½ times the 1939 level. The numbers employed on marine engineering totalled 67,600 in November, compared with 72,000 in June, 1946, and 52,200 in June, 1939. Female labour, which now accounts for 5·2 per cent. of the total (at the war-time peak it accounted for 16 per cent.) is more than three times the pre-war level.

The rise in labour costs has alarmed shipbuilders, since it is said to be a high proportion of total building costs. Average weekly earnings have fallen, however, from 129*s.* 5*d.* in July, 1946, to 127*s.* 11*d.* in April, 1947, but were still 113 per cent. greater than in October, 1938. Average increases in hourly earnings on the pre-war level were 96 per cent. for men, 99 per cent. for boys, and 104 per cent. for all workers. The announcement, towards the end of last year, that shipbuilders had decided to abandon payment by results caused considerable alarm among workpeople, following closely, as it did, on the Government's decision to reduce the industry's steel supplies. This will affect some 40 per cent. of all labour employed and may cause serious unrest.

In October, shop stewards from 19 of the Clydeside shipyards decided by 50 to 36 to accept the staggered hours scheme, which provides for each of the five groups into which the industry has been divided to work only half a shift on a different weekday, with a general resumption of work on Saturday mornings. The employees of John Brown and Company, Clydebank, decided not to accept Saturday morning work, and efforts are now being made to secure general agreement throughout the industry. The fears of unemployment, made acute by the rumours of material shortages, made it difficult for trade-union representatives to accept any schemes which may affect earnings, and the decision of shipbuilders concerning payment by results is hardly calculated to improve the situation.

A recent collective agreement of considerable importance was signed in October by representatives of the Shipbuilding Employers' Federation and the Confederation of Shipbuilding and Engineering Unions regarding the recruitment and training of apprentices, which will be controlled nationally in future by a National Joint Apprenticeship and Training Committee, and in districts by local committees. The National Joint Committee will be responsible for the preparation of a scheme covering the whole question of recruitment and training of apprentices for the industry, and the Local Joint Committees for the administration of the National Scheme in their respective districts.

Exports of ships and marine-engineering products, as given in the *Trade and Navigation Returns* for December, 1947, are set out in Table V, on page 259. During 1947, the total value of direct exports was 23·8*l.* million, compared with 9·5*l.* million in 1938. It was shown in a previous paragraph that substantial quantities of shipping under construction or on order were for hard-currency countries, including Sweden, Argentina, Canada, the United States, etc., and it is expected that exports during the current year will considerably exceed the 1947 total. Sir Stafford Cripps has set the industry the task of doubling, by the middle of 1948, the rate of exports which it achieved in the last quarter of 1946, and of producing a further increase by the end of 1948 equivalent to 166 per cent. of the October-December rate last year. At the prices prevailing in the fourth quarter of 1946, the monthly rates of exports which the shipbuilding industry is set to achieve are 1½*l.* million by the middle of 1948, and 2½*l.* million by the end of 1948, compared with 750,000*l.* for the last quarter of 1946. Most of the tonnage then under construction was being completed for British owners, and it is not expected that the industry will have any difficulty in reaching its targets; nor should any failure to reach them prejudice the industry's ability to obtain steel, in view of the following statement in the White Paper on *Capital Investment*: "The question whether it is better to build ships for immediate sale abroad or to build them for trading under the British flag has been carefully examined and the conclusion has been reached that it is at present quite as advantageous to build ships for British owners as for export, even where the exports are to hard currency countries."

Activity in British shipyards should remain at a high level, work on hand and orders received being sufficient to provide full employment for the next two to three years. Rising costs, which may lead to further cancellations of orders, probably constitute the main threat to continued prosperity. Competition is not serious at present, though it may grow as war-time damage is repaired in Continental shipyards. Competition from the American industry, which lacks experience for building specialised shipping, and which has suffered from extensive strikes during the past year, is unlikely to be felt. The present high level of demand is unlikely to last beyond 1950, however, though the world shortage of oil tankers may not be overtaken for at least five years. When demand begins to fall, competition from every quarter will have to be taken seriously and particular attention paid to costs, which, it is alleged, do not compare very favourably with certain Continental costs—for example, those of Italian shipyards.

LABOUR NOTES.

ACCORDING to official figures relating to the coal-mining industry, absenteeism showed an appreciable reduction during the week which ended on February 21. Voluntary absenteeism among all colliers, at the coal face and on the surface, was 6·01 per cent., compared with 6·17 per cent. in the previous week, and involuntary absenteeism fell from 5·68 per cent. to 5·43 per cent. The output per man-shift in the week which ended on February 21 averaged 1·10 tons overall, the same as in the previous week, and 2·89 tons at the coal face, against 2·92 tons in the previous week.

Skilled maintenance employees in the heavy chemical industry have received an increase of 1¾*d.* an hour. Provincial workers now receive 2*s.* 10*d.* an hour, while the rate in the London area is 2*s.* 11¼*d.* an hour. The Association of Chemical and Allied Employers and the Amalgamated Engineering Union are parties to the new agreement.

Mr. L. P. Lord, chairman of Messrs. The Austin Motor Company, Limited, gave particulars last week of "a production-incentive scheme which will, it is believed, recognise the employees' efforts and, at the same time, help to increase the company's exports. Under it, all employees who qualify to take part will vote in a weekly ballot for prizes the value of which will be proportionate to production. Starting with a weekly production figure of 1,700 vehicles, an output which has already been reached, the awards include one of 75*l.*, one of 37*l.* 10*s.*, one of 18*l.* 15*s.*, and two of 9*l.* 7*s.* 6*d.* Doubled production (3,400 vehicles a week) would give awards of 712*l.* 10*s.*, 356*l.* 5*s.*, 178*l.* 2*s.* 6*d.*, and two of 89*s.* 1*s.* 3*d.* All would be subject to income tax. The scheme will include all Austin employees at the Longbridge works who have been in the employment of the company for three consecutive months, with the exception of those check employees who have not qualified for good time-keeping bonus during the qualifying period and those who, in the opinion of the supervisory staff, have not contributed fully to the production effort.

In the February-March issue of the Transport and General Workers' *Record*, the Metal and Engineering section report that at a meeting on February 11, the General Executive Council of the Confederation of Shipbuilding and Engineering Unions decided to present, to the engineering and shipbuilding employers, the wage claims which they have formulated. These claims are, so far as the engineering industry is concerned, national consolidated minimum rates of 5*l.* 15*s.* a week for skilled operatives, 5*l.* a week for unskilled persons, *pro rata* adjustments in the wages of intermediate grades, the maintenance of existing differentials, and the fixing of piece-work prices and bonus basis times at such levels as will enable a workman of average ability to earn not less than 20 per cent. on the new consolidated rates.

"Long and careful consideration," it is stated, "was given by the Council to the implications of the Government's White Paper on personal incomes, costs, and prices, but it was decided to proceed with the claims. It is nearly two years since any increase was granted, and throughout that period no progress has been made with the proposed new wage structure for the industry. At its annual meeting in May, 1947, the Confederation was instructed to proceed with a wage revision, and before that date the wages structure had been under review; but no adjustments have resulted. For these reasons, and because of the low minimum rates now applicable, the unions reached their conclusions."

It was also decided to proceed with an application for increases in the wage rates of employees in the shipbuilding and ship-repairing industries. Here, the claim is for national minimum consolidated rates of 5*l.* 19*s.* a week for craftsmen and of 5*l.* a week for unskilled operatives with percentage adjustments for piece-workers.

About 600 employees of the Ipswich engineering firm of Messrs. Ransomes and Rapier, Limited, ceased work on Monday last week as a protest against the introduction of four Polish machinists. The strikers decided on Thursday to return to work on the following Monday, and to leave the issue to be dealt with nationally by the Confederation of Shipbuilding and Engineering Unions and the Engineering and Allied Employers' National Federation. "Meanwhile," said Mr. R. R. Stokes, M.P., the managing director of the firm, "the Poles will stay." Mr. Isaacs, the Minister of Labour and National Service, stated at question time in the House of Commons on Thursday that he could not allow urgent vacancies to remain unfilled, or use his powers of direction to compel British men to take these jobs while suitable unemployed Poles were available.

GAS TURBINES FOR MARINE PROPULSION.

Fig. 27.

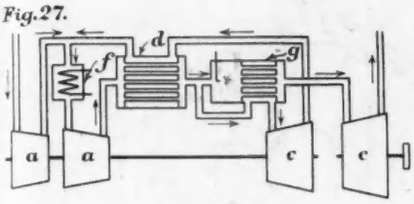
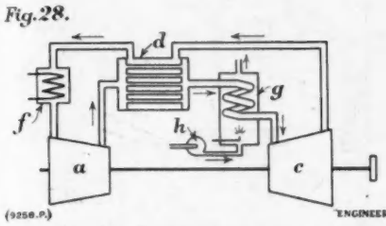


Fig. 28.



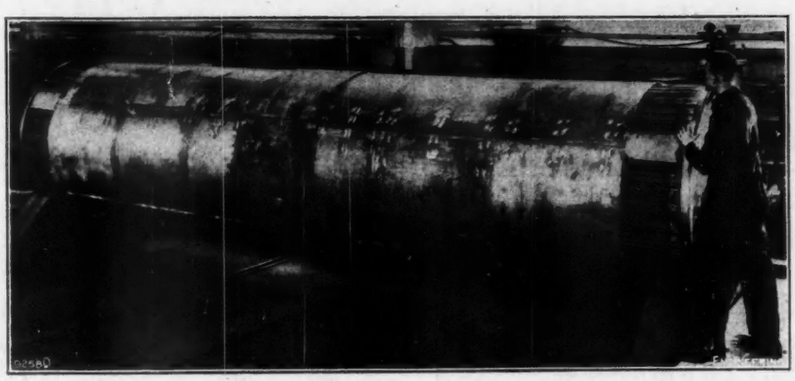


FIG. 29. HEAT EXCHANGER OF SULZER GAS TURBINE.

THE GAS TURBINE AS APPLIED TO MARINE PROPULSION.*

BY T. A. CROWE, M.Sc., M.I.Mech.E.

(*Concluded from page* 239.)

IN addition to the open cycle already considered, there are two other constant-pressure gas-turbine cycles which are being developed, namely, the semi-closed cycle and the closed cycle, which are shown in their simplest forms in Figs. 27 and 28, respectively, on this page. In these diagrams, *a* is the compressor, *c* the turbine, *d* the heat exchanger, *f* the precooler, *g* the air heater, and *h* the combustion-air fan. In the semi-closed cycle (Fig. 27) which has been developed by Messrs. Sulzer Brothers, the compressed air, after being preheated in the heat exchanger, divides into two parts. One part passes to the combustion chamber and is used for the combustion of the fuel oil; the other part passes through an air heater, consisting of numerous tubes which are heated by the gases from the combustion chamber. In this way, the combustion gases are cooled to about 1,200 deg. F. before passing to the power turbine, where they are expanded down to atmospheric pressure and discharged to the atmosphere. The other part of the compressed air, in flowing over the air-heater tubes, is also raised to the same temperature of 1,200 deg. F. This air does not become polluted with combustion gases, and it is expanded in a turbine down to a medium pressure, and is then passed through the heat exchanger. Finally, it is cooled off to a low temperature in a water-cooled precooler, and then enters the second compressor, thus completing the closed part of the cycle. The first compressor draws in from the atmosphere sufficient air to balance the quantity being used for combustion and being discharged through the power turbine.

The closed cycle, Fig. 28, has been developed by Escher Wyss, and is known as the A-K plant, after Professor J. Ackeret of the Swiss Institute of Technology and Dr. C. Keller of Escher Wyss, who have been responsible for its development. In this cycle, the compressed air, after passing through the heat exchanger, is heated indirectly in the air heater, which is similar in principle to the superheater of a steam boiler. The air remains completely free from combustion-gas impurities, and the turbines and heat exchanger will therefore remain clean and free from corrosion for an indefinite period. After the air has left the turbine and passed through the heat exchanger, it is cooled to a low temperature in a water-cooled precooler before entering the compressors, which return it again, through the heat exchanger, to the air heater. The closed cycle is thus completely sealed off from the atmosphere, and, while the plant is running at a steady load, only a small quantity of air has to be pumped in to make up for leakage losses. This make-up air is well filtered, so that no dust or salt particles can enter the circuit to harm the blades of the compressors or turbines. In normal operation, the closed cycle is supercharged, so that, even on the low-pressure side, the pressure is several times that of the atmosphere, with the result that the compressors and turbines are surprisingly small for a given output, being in this respect comparable to back-pressure steam turbines. For this reason, the closed-cycle gas turbine is particularly suited to installations of large power, and outputs of 100,000 h.p. may be obtained on a single shaft, while the centrifugal stresses in the turbine blades are, on account of the comparatively small rotors, kept down to a permissible figure.

This plant might more correctly be called a hot-air turbine and is analogous to an ordinary steam turbine, with pure air taking the place of the circulating steam and water. The air heater corresponds to the boiler and superheater, the precooler corresponds to the condenser, and the compressor represents the feed pump. There are two principal differences in this analogy. Firstly, in a steam plant, the steam condenses to water after passing through the turbines, and may therefore be raised to the boiler pressure by a comparatively small feed pump, whereas in the air cycle the air must be compressed in the gaseous state, and therefore requires considerable power to compress it and return it to the air heater. Secondly, the high temperatures which lead to high efficiencies may be used in the closed-cycle gas turbine without being accompanied by excessive pressures, as in a steam plant. High superheat temperatures may also be used, of course, in steam plants, but the resulting increase of efficiency is not particularly great, since most of the heat is still taken into the circuit as latent heat of evaporation at a comparatively low temperature.

These three types of gas turbine are all suitable for marine propulsion, and there are basic similarities. All three operate on the same basic constant-pressure cycle (the Joule cycle of Figs. 5 and 6), and with each the efficiency may be increased by enlarging the heat exchanger, by incorporating intercoolers between the stages of compression, and by reheating between the stages of expansion, thus making an approach to the Ericsson cycle, and hence to the Carnot-cycle efficiency. The greatest interest, however, lies in their differences, particularly in the method of heating the working air, in the design of the heat exchangers, in the control of output, and in various other matters.

In the open cycle, the air is heated merely by burning fuel in it—an ideally simple way, involving the use of a comparatively small and light combustion chamber, in which the rate of heat release may be over 1,000,000 B.Th.U. per cubic foot per hour in marine plants. This simplicity is, however, accompanied by the disadvantage that the combustion gases pass through the turbine and heat exchanger, and may form deposits which reduce the efficiency of the turbine and the heat-transfer rate in the exchanger, particularly with the cheaper quality of fuels, such as boiler oil. These items of the plant would therefore have to be cleaned periodically. The compressors would also require periodic cleaning and overhaul, though no doubt less frequently than the turbine, on account of the dust or salt which may adhere to the blades or erode them and so alter their exact profile. Tests on axial compressors have shown a reduction of 1½ per cent. in efficiency after running for 12 hours on air drawn from a heavy engineering workshop.

In the semi-closed cycle, the air heater adds to the size and weight of the plant, and so does the precooler installed in the closed part of the cycle. The air heater, however, is comparatively small, even in plants of large output, for three reasons. The pressures on both sides of the tubes are very high, and therefore the heat-transfer rates are high. The pressure inside and outside the tubes being approximately equal, the stresses are low, and the tube temperatures may therefore be very high, so that the heat-transfer rates are further increased. Thirdly, only a part of the heat in the fuel has to be transmitted through the tube walls, since a considerable portion remains in the combustion gases which pass to the power turbine. The power turbine operates on combustion gases, and therefore will require periodic cleaning as in the open cycle, but the turbine which drives the compressors operates on pure air, and the heat exchanger is also free from combustion gases.

Heating the air indirectly in the closed cycle involves the use of a comparatively heavy and bulky air heater, incorporating small-diameter tubes heated to a temperature somewhat above the maximum temperature of the working air. It is interesting to note, however, that, owing to the fact that the heat-transfer coefficient of air varies almost directly with pressure and velocity, the tube-wall temperature is kept down to within 100 deg. F. of the final air temperature, due to the excellent heat transfer between the tube and the air inside it. The tube stresses are of the order of 1 ton to 2 tons per square inch. Since only pure air, unpolluted by combustion gases, passes through the turbine and heat exchanger, there is no possibility of these becoming fouled or corroded. The only parts subjected to the action of the combustion gases are the outsides of the air-heater tubes. In addition, since the compressors are not constantly drawing in fresh air from the atmosphere, they will maintain their efficiencies for an indefinite period.

The size and details of the heat exchanger differ in the various cycles. The tubular contra-flow type is the one most favoured, on account of its simplicity and reliability, although considerable development work is being carried out on the rotating regenerative type; this would be smaller and lighter for a given duty, but the difficulty of obtaining effective sealing round the rotor, between the high- and low-pressure sides, has so far prevented its adoption. In the open cycle, the heat exchanger is built up of tubes which cannot be smaller than about ¾-in. bore, on account of the possibility of their becoming choked by deposits from the combustion gases, and so requiring to be cleaned internally. In the semi-closed cycle, the heat exchanger operates with pure air on both sides of the tubes, so that small-bore tubes may be used without any fear of their becoming choked. The nest of tubes for the Sulzer 7,000-9,000 shaft horse-power plant is shown in Fig. 29, herewith. The use of such small-bore tubes gives a very large surface area for a given cubic capacity of heat exchanger, and since the air, even on the low-pressure side, is considerably above atmospheric pressure, the heat-transfer rates are comparatively high. The compressed air cannot, however, be preheated to a temperature approaching that of the hot air exhausting from the turbine into the heat exchanger, since the quantity of exhaust air is about 40 per cent. less than the quantity of compressed air being preheated on its way to the air heater. In the closed cycle, the tubes are also very small, and may be as fine as ¼ in. in bore, since both inside and outside the tubes there is again only pure air. In addition, the air pressures are normally about six or seven times those in the open cycle, with a corresponding improvement in the heat-transfer rates—a point which has already been illustrated in Fig. 26. As a result of these excellent characteristics, it is possible to obtain a heat-exchanger effectiveness of over 90 per cent. in commercial installations, and it is this fact that is largely responsible for the high overall efficiencies obtained with the closed cycle.

The method of controlling the power differs in the various types of gas turbines. In the open cycle, the power is controlled by varying the quantity of fuel supplied to the combustion chamber, and thereby varying the turbine-inlet temperature. At the same time, it is best to reduce the speed of the machines, in order that the altered flow conditions in them should be partly corrected. In a marine plant, the speed of the power turbine falls off as the speed of the propeller

* The Twentieth Thomas Lowe Gray Lecture, delivered to the Institution of Mechanical Engineers, London, on Friday, January 23, 1948. Abridged.

GAS TURBINES FOR MARINE PROPULSION.

Fig. 30.

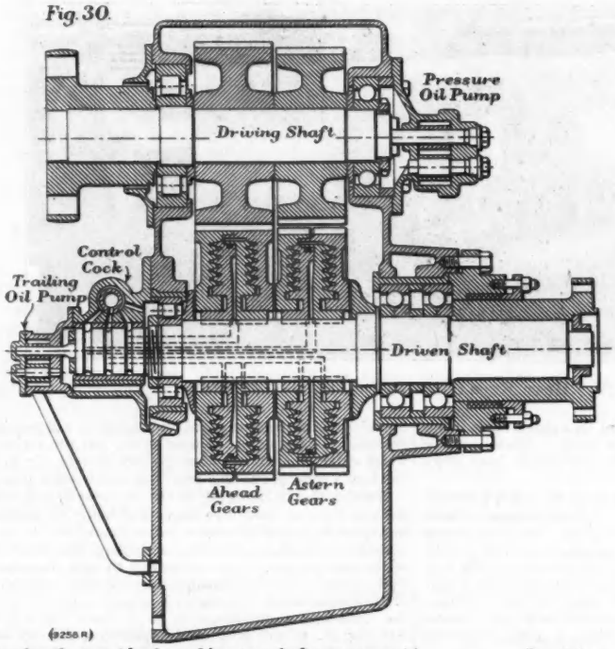
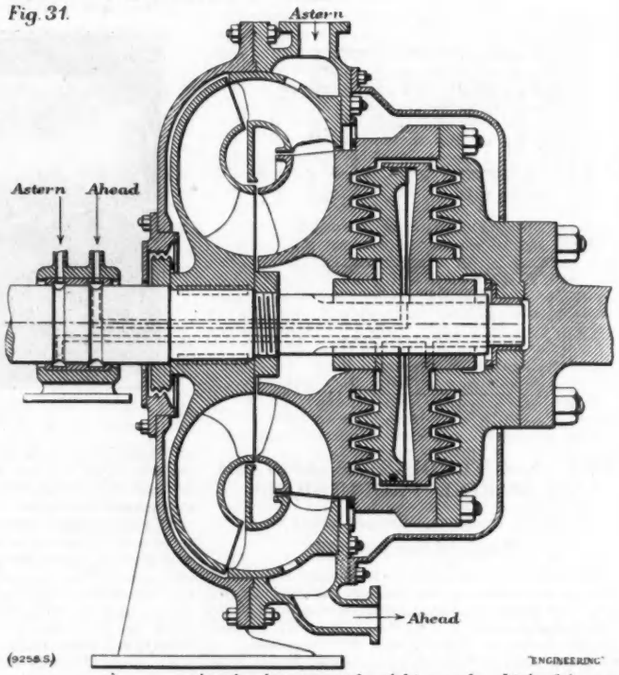


Fig. 31.

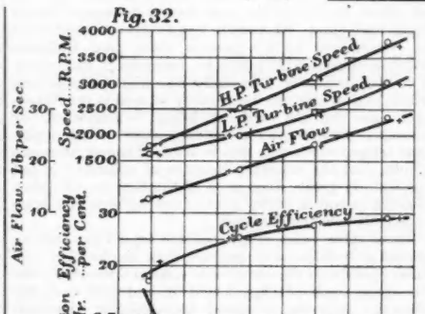


is reduced, at part loads, and in a two-shaft arrangement the speed of the high-pressure turbine and compressors may be suitably adjusted. Even so, however, there is a serious loss of efficiency at part loads, owing to the reduced turbine-inlet temperature. The output of the semi-closed cycle gas turbine is adjusted by varying the pressures in the circuit while the temperature at the turbine inlets remains practically unchanged; this is carried out by altering the speed of the high-pressure turbine, and hence the speed of the compressors. The pressure ratios and mass flows vary with the change of speed, but the velocity ratios in the blading remain much the same. It is interesting to note, however, that, in marine plants, the law applying to the variation of propeller speed with a change of power is exactly the same as that which ensures the maximum efficiency of the useful-output turbine. As a result, the efficiency of the whole plant only falls off very slightly at part loads. The output of the closed cycle is very simply increased by introducing more air into the working circuit, either from a compressed-air reservoir or by means of a small reciprocating or rotary compressor. As a result, the pressures and densities of the air throughout the circuit rise, with a proportional increase in power. The supply of fuel to the air heater must be increased, of course, otherwise the turbine-inlet temperature will fall. However, the heat capacity of the tubes in the air heater is sufficient to prevent any sudden change of temperature occurring. In a similar manner, the output is decreased by releasing air from the working circuit. The pressure ratios and temperatures throughout the circuit remain the same at all powers, so that, provided the turbines and compressors are kept running at a constant speed, the velocity ratios will not alter, and therefore a high efficiency will be maintained at all loads.

A gas turbine, unlike the steam turbine, is not self-starting, but must be run up to a considerable speed by an auxiliary motor before the compressor will deliver sufficient air to operate the turbine. The power of the starting motor is about 4 or 5 per cent. of the net output of medium-sized plants. An electric motor may be used, receiving its power from the ship's auxiliary Diesel generators; alternatively, a compressed-air motor could be used, but this would require a rather bulky high-pressure air reservoir.

In selecting a system of reversing, it is not possible to use a simple astern turbine as in steam installations, since the windage losses in an idling gas turbine would be excessive, and would cause serious troubles due to overheating. An astern gas turbine could only be used if clutches were fitted to both the ahead and astern turbines, so that the one not in use could be disconnected from the reduction gears. The provision of the necessary stop valves in the high-temperature gas pipes would be troublesome, and serious temperature stresses would be set up by the sudden admission of the hot gases to the astern turbine. There are, however, four means of obtaining satisfactory reversing without having to reverse the turbines: namely, a variable-pitch propeller,

Fig. 32.



an electric drive, reversing gears, and a hydraulic reversing coupling of the Föttinger type. The variable-pitch propeller is attractive in many ways, for not only does it provide a simple and rapid method of manœuvring, but it also enables higher propeller efficiencies to be obtained when the ship is operating outside its designed conditions. For example, when the ship's resistance has increased, owing to bad weather or a fouled hull, the pitch of the blades may be adjusted to suit the reduced speed of the ship. The general characteristics of variable-pitch propellers have recently been fully described by Mr. J. L. Taylor (*Proc. I. Mech. E.*, vol. 155, page 211 (1946)). It does appear, however, that the modern robust designs have overcome the difficulties which were experienced with the early types, and which gave the variable-pitch propeller a bad name. Satisfactory results have now been obtained on ocean-going ships of 3,500 h.p. per shaft, and there is no reason to suppose that the variable-pitch propeller will not be suitable for the largest powers likely to be adopted in marine service. Electric propulsion is a well-tried system of control, and the great strides which have been made in its development and application during the last few years were described by Mr. G. O. Watson, in the Eighteenth Thomas Lowe Gray Lecture.* The efficiency of this type of transmission is about 93 per cent., compared with about 97 per cent. for the geared drive, and the total cost of the machinery in a turbo-electric ship is about 5 to 6 per cent. greater. However, a saving in space and weight may be obtained in some installations by placing the synchronous motor well towards the stern of the ship, thus shortening the shafting. The ease of manœuvring, together with its proved reliability, may ensure its adoption in certain installations.

Although reversing gears have not been made for the larger powers used in marine service, interesting designs have been developed by Messrs. Modern Wheel Drive, Limited, and a cross-section of one of their gears is shown in Fig. 30, herewith. On the driving, or upper, shaft two gears are rigidly fixed, the left-hand one meshing directly with a gear running on the driven shaft below. The right-hand gear drives the second gear on the lower shaft through an idling pinion behind, so that the two lower gears, which are free to rotate on their shaft, are driven continuously in contrary directions. Inside each of these two driven gears is a multi-cone oil-operated clutch. When it is desired to go ahead, the clutch in the left-hand gear is engaged by admitting oil under pressure through the appropriate duct in the shaft, so that the gear is gripped firmly to the driven shaft. When going astern, the clutch in the left-hand gear is released and that in the right-hand gear engaged. Reversing gears of this type have already been made for powers up to 1,600 shaft horse-power, and designs have been prepared for transmitting 24,000 shaft horse-power. Fig. 31, herewith, shows diagrammatically a section through a hydraulic reversing-mechanism, which may be installed between the turbine and reduction gears or between the reduction gears and propeller, according to where the torque and speed conditions are most suitable. Ahead drive is transmitted directly through the multi-cone clutch, oil under pressure being admitted for this purpose between the two multi-cone discs. These are keyed on to the driving shaft, and the oil pressure forces them into contact with the driven member, thus locking the two shafts together. The astern drive is obtained by releasing the clutch and filling the blade system of the Föttinger-type reversing coupling with oil. The efficiency of the astern drive will be about 60 to 70 per cent., but the only losses which will occur while going ahead will be due to windage in the hydraulic coupling.

As already noted, one of the principal reasons for the slow development of the gas turbine was the difficulty of obtaining high-temperature resisting materials, and the metallurgist continues to find the demands of the gas-turbine designer quite insatiable. The attainment of higher efficiencies through higher turbine-inlet temperature will always be limited by the properties of the available materials. Considerable work has been done in developing ceramics for turbine blades, but the brittleness of the material will probably prevent its introduction into marine gas turbines, where long life and reliability are essential. The brittleness of pure ceramics may be reduced by incorporating powdered metals, but for marine use metal blades will undoubtedly hold the field, at any rate

* See ENGINEERING, vol. 161, page 142 (1946).

GAS TURBINES FOR MARINE PROPULSION.

Fig. 33.

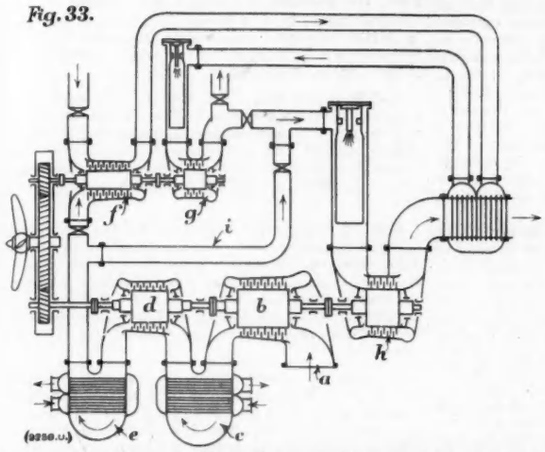
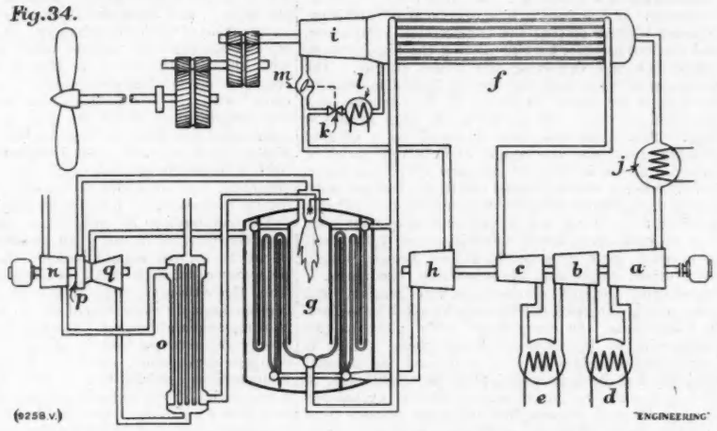


Fig. 34.



for some time to come. Metals for gas-turbine components must combine a variety of properties. They must, of course, retain a high strength, so that neither fracture nor excessive creep occurs at the high temperature employed. Turbine blades must be sufficiently tough to withstand considerable vibrational stresses, and, in the open-cycle gas turbine, the metal must be capable of withstanding the erosive action of the ash particles in the gas stream. Resistance to oxidation and scaling is also necessary, but, fortunately, most creep-resisting alloys are satisfactory in this respect and no alloying elements need be added specifically for this purpose. Various components, such as the blades, rotor, and combustion-chamber liner of the open-cycle gas turbine, and the air-heater tubes of the closed-cycle gas turbine, must withstand the corrosive action of the combustion gases. When heavy fuel oils containing appreciable quantities of sulphur are used, the corrosive attack may be serious on account of the tendency of nickel, a constituent of all existing heat-resisting metals, to react with the sulphurous gases to form the weak nickel sulphide. Special adjustments to the composition of the metal must be made on this account, and precautions must be taken in the design to reduce the occurrence of corrosion. It is also necessary for the metal to be stable, so that internal changes do not gradually occur at the high temperatures involved, resulting in changes of micro-structure, or reduction of creep strength and increase of brittleness. This also calls for the addition of small quantities of special elements to the alloy. With regard to manufacture, it is important that the metal be uniform in quality, so that the results of tests on a few samples may with confidence be expected to apply generally. Finally, the metal must not be too difficult to fabricate, and must be suitable for casting, forging, machining or welding, as required.

The essential features of a gas turbine for marine service are reliability, long life, low upkeep cost, economy, space occupied, and weight. I have put reliability first because it is of the utmost importance for marine service. Most ships must be capable of trading to any part of the world, and must be capable of being maintained either by their own staff, or by the very limited shore facilities which exist in some ports of the world. Also, it is not feasible in a ship to carry complete stand-by plant for the main propulsion machinery. A breakdown of the machinery may, in an extreme case, result in the total loss of the ship and its cargo, as well as the lives of the crew. In other cases, a breakdown at sea may mean very heavy costs for towing and salvage claims; if it occurs in harbour it means the whole ship is out of action, and may result in a financial loss, to the owners, of several thousands of pounds per day. In view of the small number of moving parts required, it seems likely that the gas turbine will ultimately prove as reliable as the older forms of prime movers. This is specially the case with the closed-cycle gas turbine, because the turbines are operating on clean air.

Regarding the second requirement, long life, it is the general practice to-day to design gas turbines for marine propulsion for a running life of not less than 100,000 hours at full load and temperature. This corresponds to a useful life of 20 to 25 years. The long life required, compared with the few hundred hours for which aircraft gas turbines are designed, naturally involves working at lower temperatures and lower stresses. Owing to the advances which have been made in recent years in materials for use at high temperatures, it is now possible to design and produce a gas turbine to operate for 100,000 hours with a gas inlet temperature of 650 deg. C., or 1,200 deg. F. There is, however, a much greater degree of uncertainty concerning the behaviour of the high-temperature materials in a marine plant than in an aircraft gas turbine. It is quite practicable to run creep tests for a period equal to the whole life of an aircraft gas turbine, so that exact information can be obtained, and the turbine may be operated at temperatures and stresses which are only slightly lower than those which would cause failure during its lifetime. It is quite impossible, however, to run creep tests for the 100,000 hours required by a marine plant, and in all probability, at the present rate of metallurgical development, the particular metal tested would be superseded by a superior alloy before the end of a long creep test, so that the information would be out of date before it was obtained. The marine designer must therefore base his calculations on data obtained by extrapolating creep curves, based on tests of less than 10,000 hours, and must include a generous factor of safety to allow for possible errors in extrapolating more than ten times beyond the range of certain knowledge.

Low upkeep cost is very closely associated with reliability, and in view of what has already been said about reliability, it follows that, once the initial teething troubles have been overcome, the costs of repairs should compare favourably with other types of prime movers. In the case of the open-cycle gas turbine, there will be the cost of cleaning the heat exchanger, and also, possibly, the turbine and compressor blading. In the case of the closed cycle, there will be the cost of cleaning the air heater, if this is required. Experience to date, however, indicates that, owing to the high metal temperature of the tubes, the complete combustion obtained and the high gas velocities used, these tubes keep clean indefinitely. At the worst, the cost of cleaning the air heater would compare favourably with the cost of boiler cleaning in a steam-turbine installation, because only the gas side of the tubes would require cleaning.

For a vessel of 5,000 to 10,000 shaft horse-power per shaft, a gas turbine can be constructed to have a fuel consumption of about 0·44 lb. to 0·46 lb. per shaft horse-power per hour, corresponding to a thermal efficiency of 30 per cent. to 32 per cent., based on the gross or higher calorific value of the fuel. When developments in metallurgy allow us to increase the initial temperature of the air entering the turbine by a further 150 deg. to 1,350 deg. F., the gas-turbine fuel consumption will be reduced to about 0·38 lb. per shaft horse-power per hour, that is, to approximately the same as the Diesel engine. With the open-cycle gas turbine, it will probably be necessary to use a distillate fuel oil corresponding to a heavy Diesel-oil or a light boiler-oil, in order to maintain cleanliness of the turbine and heat exchanger. In the case of the closed-cycle gas turbine, however, it should be possible to burn any oils which can be burnt in a steam boiler, because the air heater is virtually an "air boiler." In making a comparison of running costs, the consumption of lubricating oil should be taken into account. In this respect, a gas turbine will compare favourably with a steam turbine, and will be very much more economical than a Diesel engine. The cost of lubricating oil and cylinder oil in a marine Diesel engine may amount to as much as 15 per cent. of the cost of fuel oil, whereas in a corresponding steam or gas turbine the cost will be only about 0·5 per cent.

The space occupied by a gas turbine, including all the auxiliaries required for both main propulsion and ship's purposes, is less than that required for a modern steam turbine or Diesel installation. It is impossible to give a typical figure for the saving in space, since it varies so greatly between the various classes of ship and the type of gas turbine. In a cargo vessel of 5,000 to 10,000 shaft horse-power, however, a closed-cycle gas turbine would give a saving of about 25 per cent. of the space required by a steam installation. An open-cycle gas turbine may be made very compact if a high efficiency is not required, so that intercoolers can be dispensed with, and a small and low-efficiency heat exchanger is sufficient. In large ships, and particularly in passenger ships, however, the space saved by the simplicity and compactness of the actual plant may be more than compensated by the valuable space taken up by the large air-inlet and exhaust ducts, passing through all the decks. These ducts have to pass about five times the quantity of air and exhaust gas required by a similar steam, Diesel or closed-cycle gas-turbine installation, and, since pressure losses must be kept small, velocities cannot be high, and so the sectional areas must be large. The weight of a marine gas-turbine installation is considerably less than that of the corresponding steam or Diesel plant, but again, as in the case of the space occupied, comparative figures can only be given for particular cases. The weight of a steam installation, including shafting, propellers and all auxiliaries, may vary from about 220 lb. per shaft horse-power in a cargo vessel, where low fuel consumption is necessary, to about one-eighth of that figure in a naval vessel. The weight of a gas turbine also varies greatly according to the service for which it is required, but, as an example, it may be stated that a closed-cycle installation in a cargo vessel of 5,000 to 10,000 shaft horse-power would weigh a little over half the weight of a corresponding Diesel installation, or about two-thirds that of a steam plant.

In most marine installations, particularly in the larger sizes, a two-turbine arrangement would be adopted. The high-pressure turbine would drive the compressors only, while the low-pressure one would supply the useful output of the plant. This would not only reduce the length of the layout, but also increase the stability of operation. The speed of the power turbine and the propeller may be reduced, while keeping the compressors running at a high speed and hence well above their "surging" condition. It is interesting to note that, in a gas-turbine installation, there is considerable flexibility in the disposition of the various components in the engine space. The heat exchanger, precoolers, and combustion chamber or air heater may be arranged in any position, and at any convenient height relative to the turbines, unlike a steam plant, where the positions of condensers, extraction pumps, etc., are fixed relative to the turbine.

The first gas turbine installed in a sea-going craft was built by Messrs. Metropolitan-Vickers, and installed in a motor gunboat which underwent successful trials in August, 1947.* This boat was originally powered by three 1,250-brake horse-power Packard engines, each driving a separate propeller. The centre engine was replaced by an open-cycle gas turbine, operating without a heat exchanger and developing 2,500 shaft horse-power at full load. The nine-stage axial-flow compressor is driven by a two-stage turbine connected directly to it. The straight-through annular combustion chamber is placed between the compressor and the high-pressure turbine rotor. The power turbine has four stages, and rotates independently of the compressor and high-pressure turbine, driving the propeller through reduction gears. No arrangements for reversing were pro-

* See ENGINEERING, vol. 164, page 271 (1947).

vided, manœuvring being carried out on the two reciprocating engines.

In 1942, the United States Navy sponsored the construction of a 2,500-s.h.p. gas turbine by the Elliott Company. It is a two-turbine arrangement, the high-pressure turbine driving the low-pressure compressor, and the low-pressure turbine driving the high-pressure compressor and supplying the useful output. The compressors were both of the positive-displacement screw type developed by Mr. A. J. R. Lysholm, and the turbines were both of the multi-stage axial-flow type. This plant was first operated as a unit in October, 1944, and the results of full- and part-load tests are shown in Fig. 32, on page 262, from which it will be noted that a thermal efficiency of 29 per cent. (based on the lower calorific value of the fuel oil) was obtained at full load, and 20 per cent. at quarter load.

In an open-cycle layout comprising two 7,000 shaft horse-power units, proposed by Messrs. Brown, Boveri, for a mixed cargo and passenger ship, the power is transmitted through double-reduction gearing, and manœuvring is carried out by variable-pitch propellers. In these units, the compression takes place in two stages with an intercooler between them. There is only a single turbine in each unit, and the thermal efficiency has been increased from 24·4 per cent. to 27·2 per cent. by incorporating a heat exchanger. The specific fuel consumption has been reduced from 0·571 lb. to 0·514 lb. per shaft horse-power per hour.

A higher efficiency may be obtained with the Brown-Boveri two-stage arrangement shown in simplified form in Fig. 33, on page 263. There are two shafts, one comprising the low-pressure turbine *h*, and two compressors *b* and *d*, while the other comprises the high-pressure turbine *g* and compressor *f*. Both are geared to the propeller shaft, and in normal operation air would enter at *a* and pass successively through the three compressors, being cooled between each in the intercoolers *c* and *e*. Reheating between the turbines has been adopted. The by-pass *i* is used to prevent surging in the compressors *b* and *d*, when the speeds of the propeller and turbines have fallen at part loads. This pipe can also be used to cut out the high-pressure set completely, if required, and the set may then be disconnected from the gear by removing its pinion. In addition, should trouble develop on the low-pressure set, the high-pressure set may be used alone, giving about one-quarter of full power.

A Sulzer semi-closed cycle plant of 7,500 shaft horse-power, for a marine installation, is under construction, and will operate on the cycle shown in Fig. 27, except that the main compressor will be divided into two stages with an intercooler between. The heat exchanger of this plant, with its small-bore tubes, is shown in Fig. 29. The efficiency is estimated to be 30 per cent., based on the higher calorific value of the fuel, and by introducing a number of thermodynamic improvements, such as reheating, the efficiency could be raised to 32 per cent.

A John Brown-Escher Wyss closed-cycle plant of 6,000 shaft horse-power is shown schematically in Fig. 34, on page 263. The thermal efficiency is estimated at 31 per cent., giving a fuel consumption, for propulsion only, of 0·44 lb. of Bunker C oil per shaft horse-power per hour. In marine installations, the combustion in the air heater takes place at an elevated pressure, the combustion air being compressed to about 30 lb. per square inch gauge pressure. In this way, the size and weight of the air heater are considerably reduced, on account of the higher heat-transfer rates obtained. The cost is also reduced, since the reduction in the quantity of special steel tubes more than balances the extra cost of the supercharging set.

In Fig. 34, the closed circuit is on the right-hand side of the diagram, while the combustion circuit is shown to the left of the air heater. In the closed circuit, the air is compressed in three stages by the compressors *a*, *b* and *c*, from a pressure of 100 lb. to 430 lb. per square inch absolute. Between the compressors, the air is cooled to its original temperature, that is, to within 15 deg. F. of the sea-water temperature, by the intercoolers *d* and *e*. The compressed air passes through the heat exchanger *f* before entering the air heater *g*, where it flows through the various tubes and is heated to 1,200 deg. F. and then passes to the turbines. The high-pressure turbine *h* drives the compressors only, the speed remaining approximately the same at all loads. The variable-pitch propeller is driven through double-reduction gearing by the low-pressure turbine *i*, and at any particular speed of the ship the pitch of the propeller, and consequently the speed of this turbine, are adjusted so as to give the best combination of propeller and turbine efficiencies. From the low-pressure turbine, the air passes through the tubular heat exchanger *f* and the water-cooled pre-cooler *j*, before again entering the compressors to repeat the cycle.

As already pointed out, the power developed by the plant is normally raised or lowered by introducing air to, or discharging it from, the closed circuit. When, however it is required to reduce power for a short time only (*e.g.*, when manœuvring and changing the propeller pitch through the neutral position), it is unprofitable to vary the load in this way, on account of the auxiliary power required to recharge the closed circuit. In this case, the load is reduced by by-passing a portion of the working air past the low-pressure turbine, through the valve *k*, and the cooler *l*, which is fitted to prevent overheating of the heat exchanger. A throttle valve *m*, at the low-pressure turbine inlet, is interconnected with the by-pass valve, so that it partly closes as the latter opens, thus maintaining a constant pressure-drop across the low-pressure turbine. In this way, the pressure drop across the high-pressure turbine is maintained constant, so that stable operation of the high-pressure turbine and compressors is ensured. Such a throttling process, of course, involves a loss of efficiency, but, since this occurs only for short periods during manœuvring, it is not serious.

The combustion air enters the compressor of the supercharging set *n*, and then passes at a pressure of about 30 lb. per square inch to the combustion-air preheater *o*, where it picks up much of the waste heat from the exhaust gases. The heated air enters the combustion pots at the top of the air heater, where fuel oil is injected and burned. The quantity of air supplied is only about 20 per cent. in excess of that required for complete combustion, and, to avoid the extremely high temperatures resulting from such a high fuel-air ratio, a proportion of the exhaust gases is recirculated back into the combustion chamber by the fan *p* in the supercharging set. After flowing over the various passes of tubes, the combustion gases leave the air heater and divide into two portions, one being returned to the combustion chamber, as already mentioned, and the other, since the pressure is here about 25 lb. per square inch gauge, is expanded down to atmospheric pressure in the turbine *q*, which drives both the compressor and recirculating fan. The exhaust gases pass through the tubes of the combustion-air preheater before passing up the funnel. The sectional areas of the air-intake and exhaust-gas ducts are, respectively, 3·5 sq. ft. and 6·2 sq. ft. for each plant; they are about half those of an equivalent steam plant, and about one quarter the size of the corresponding open-cycle gas-turbine plant.

The tubes which comprise the heating surface in the air heater are of considerably smaller bore than is customary in steam-boiler practice, since there is no possibility of internal deposits forming and requiring to be cleaned out. This, together with the comparatively low pressure (380 lb. per square inch above the combustion-gas pressure) enables tubes with a wall thickness of about $\frac{1}{16}$ in. to be used, while keeping the pressure stresses below 1 ton per square inch. The temperature stresses, on account of the thinness of the metal, are also low. The combustion gases make three passes over the tubes, in each case flowing along the tubes. The working air divides into two parts, one part entering those tubes which lie in the first pass of the combustion gases, the air and gases both flowing in the same direction. In this way, the temperature of the tube walls in the hottest part of the heater is kept well down, by the excellent heat-transfer coefficient between the tube and the relatively cool incoming air. The other part of the working air enters the tubes lying in the last pass of the combustion gases, and here the air and gases flow in contrary directions, thus cooling the combustion gases, as far as possible, before leaving the air heater. Both streams of air are heated to the final maximum temperature in the intermediate pass of the combustion gases. This arrangement of tubes gives a high rate of heat transfer, while ensuring that the highest tube temperature does not rise above 1,300 deg. F., with an outlet air temperature of 1,200 deg. F. In view of the low stresses existing in the tubes, this temperature is unlikely to give trouble, with modern heat-resisting steel tubes, within the lifetime of a marine plant.

Except for special applications to high-speed naval craft, it is essential that the gas turbine should have a fuel consumption close to that of a Diesel engine, and should be capable of burning the cheaper grades of boiler oil. Experimental gas-turbine plants have now shown that this is possible, and in the not too distant future, a growing practical experience will establish the reliability of this new prime mover. I have no doubt that, in a few years, it will secure the confidence of ship-owners, and achieve a fundamental place in the field of marine propulsion.

INTERNATIONAL CONFERENCE ON SURFACE REACTIONS.—The Pittsburgh section of the Electrochemical Society, in association with several other American scientific societies, is organising an International Conference on Surface Reactions, to be held from June 7 to 11 in the Mellon Institute of Industrial Research, Pittsburgh. Scientists and engineers from many parts of the world have been invited to participate in the conference and we understand that several are to present papers. Further particulars may be obtained from the conference secretary, Mr. R. Rimbach, 1117, Wolfendale-street, Pittsburgh, Pennsylvania, U.S.A.

CATALOGUES.

Steel Tubes.—A folder in which are set out, in tabular form, the standard dimensions and weights of steel tubes of from ¼ in. to 6 in. nominal bore, as contained in British Standard Specification No. 1387, has been published by Wellington Tube Works, Limited, Great Bridge, Tipton, Staffordshire.

Steel Wire and Strip.—The United Steel Companies, Limited, 17, Westbourne-road, Sheffield, 10, have sent us a copy of a booklet on steel wire and strip issued by Messrs. Samuel Fox and Company, Limited, Stocksbridge, near Sheffield. This contains data on this firm's various qualities of cold-rolled strip, wire and bright bars.

Bakelite Products.—A description of the production of Ecme (electronic circuit-making equipment) by Messrs. John Sargrove, Limited, is given in a recent issue of *Bakelite Progress*, published by Bakelite, Limited, 18, Grosvenor-gardens, London, S.W.1. The process is an automatic one for the production of wireless sets, and Bakelite plastics form the basis of the technique employed.

Thermal and Acoustic Insulating Medium.—Messrs. Stillite Products, Limited, Sardinia House, Kingsway, London, W.C.2, have sent us an illustrated catalogue of their material Stillite. This is stated to be a refined mineral-wool insulating medium consisting of fine springy fibres of great resilience and extreme lightness. It is used as a thermal and acoustic medium and also for the filtration of compressed gases, vapours and non-aqueous liquids. Technical and other data are given.

Drilling and Reamering.—A handy booklet giving useful information on drilling and reamering is issued by the Sheffield Twist Drill and Steel Company, Limited, Summerfield-street, Sheffield, 11, for the use of engineers, draughtsmen, and others. It includes advice on the sharpening of drills and the use of cutting tools and lubricants, and there are tables of standard sizes of drills, speeds and feeds suitable for different metals, sizes of drills for tapped holes, the weight of material removed by drilling, and hardness scales for converting from one system to another.

Selenium Rectifiers.—The principal features and characteristics of the selenium metal rectifier units manufactured by them are described in a bulletin issued by Standard Telephones and Cables, Limited, Connaught House, Aldwych, London, W.C.2. These units, which bear the registered trade mark of SenTerCel, have a wide range of applications, among which mention may be made of battery charging, electroplating, arc welding, control equipment and radio and radar apparatus. The various types of rectifier available for these and other purposes are described and illustrated, full technical details being given.

Milling and Broaching Machines.—Messrs. Cincinnati Milling Machines, Limited, Birmingham, 24, issue a quarterly pamphlet entitled *Report*. The issue for October-December, 1947, contains a description of the method of machining golf-club heads, using a 10-ton vertical duplex broaching machine with a maximum stroke of 66 in.; and the machining of agricultural tractor components on duplex ram-type milling machines. Hoppers for centreless grinders, and attachments for milling machines, are also described. The latter include a circular-milling attachment, a dividing head, a high-speed milling head, a spiral-milling attachment, several vices, a slotting attachment, etc.

Underwater Cutting and Telephone Equipment.—A pamphlet from Messrs. Siebe, Gorman and Company, Limited, Neptune Works, Davis-road, Tolworth, Surrey, gives details of the B.O.C.-Siebe, Gorman oxy-hydrogen underwater cutting outfit. Hydrogen can be used for this purpose at greater depths than acetylene, which is limited to 30 ft. A leaflet from the same firm describes their Marks I and II divers' intercommunication telephones with loudspeakers. With two divers under water, a message can be transmitted from the surface to one or both divers, or from a diver to the surface; or the two divers can speak to each other, while the surface attendant listens and interjects whenever he requires.

Steam-Generating Plant.—Messrs. International Combustion, Limited, 19, Woburn-place, London, W.C.1, have issued a handsome brochure which describes some typical boilers constructed by them, and erected in many parts of the world. They include various types of two- and three-drum boilers for the generation of steam in central power stations and industrial establishments. The firm have installed pulverised-fuel burning equipment in boilers with evaporative rates from about 30,000 lb. per hour to 440,000 lb. per hour. The efficiency and availability of these boilers are superior to those of stoker-fired boilers, although this type of plant is also built. The brochure contains, in addition, sections dealing with marine boilers and the manufacture of solid-forged boiler drums; and illustrating the firm's works and laboratories at Derby.